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TABLE OF CONTENTS

Vol. 21 February, 1938 No. 2

THE JOURNAL

Pyrometry and the Steel-Maker's Refractories 37
By R. B. Sosman
The Structure of Silica Glass by X-Ray Diffraction Studies 49
By B. E. Warren and J. Biscoe
Study of an Alumina-Silica Checker Brick from the Regenerator of a Glass Tank 55
By C. L. Thompson and E. P. Rexford
Examination of an Unusual Cast Iron 60
By G. H. Spencer-Strong
A Modification of the Bingham Plastometer 66
By J. T. Irwin and R. E. Bevis
Some Special Wear-Resisting Metals for Clay Machinery Use 69
By J. O. Everhart

CERAMIC ABSTRACTS

17—2

Abrasives 51
Art and Archeology 53
Cements 55
Enamel 56
Glass 59
Structural Clay Products 68
Refractories 69
Terra Cotta 75
Whiteware 76
Equipment and Apparatus 77
Kilns, Furnaces, Fuels, and Combustion 80
Geology 81
Chemistry and Physics 84
General 88

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PYROMETRY AND THE STEEL-MAKER'S REFRACTORIES*

By Robert B. Sosman

I. Introduction

Two decades ago the rôle of pyrometry in relation to the steel-maker's refractories was confined to their manufacture. Today its principal rôle is in their preservation.

Before presenting examples of these two contrasted applications of the art of pyrometry, may I explain a few elementary concepts, since this Lecture must not be too narrowly technical.

II. Temperature

"Pyrometry" is the art of measurement of any temperature above a dull red. The Association of Scientific Apparatus Makers has given us a quantitative definition of a pyrometer as an instrument for the measurement of any temperature above 500°C or 950°F. For lower temperatures, the terms "thermometer" and "thermometry" have become customary. What then is "temperature?" It is that quality of things that causes one object to feel warmer to the hand or cheek than some other object. This does not sound properly scientific, but you will find it very difficult to write a definition of temperature that says any more than the one just given. One is tempted to say that "temperature is the quality that causes heat energy to flow from one object to another," but what is it that flows? Heat energy is an invention of the past century, a theoretical abstraction like entropy, and a concept that many talk about but few understand. It was invented solely to fill a gap in our logical thinking. No one has seen, felt, heard, or smelled this mysterious something called heat. What we do see and feel, and recently have actually been able to hear,[1] is *change of temperature.*

This quality called temperature is the technician's most potent variable. When it changes, the whole aspect of our world changes with it. Our own bodies can not long endure an internal change of more than one degree centigrade, although we fortunately have the means to maintain our temperature in spite of wide fluctuations in the temperature of our surroundings. Recognizing its prime importance, the central mural in the home of the National Academy of Sciences in Washington depicts Prometheus transmitting the gift of fire, the catalytic agent with which Man began and has continued the conquest of his environment through changing its temperature.

III. Temperature in the Manufacture of Refractories

Before this audience little need be said about what is meant by the second part of my title, "the steel-maker's refractories." They are the brick, cements, and earthy fillers out of which he builds his furnaces, and their primary requisite is that they shall endure high temperature, since steel-making is the hottest of the large-scale high-temperature arts. What part does pyrometry play in their manufacture?

There is no good reason in the nature of the case why a high temperature is necessary at all in the manufacture of refractories. Some refractories, in fact, are never heated until they reach their final position of service; examples are the quartz-mica schist used in lining the Bessemer converter for the acid Bessemer process, the firestone (quartzite) blocks sometimes used as a lining for the soaking pit, the olivine rock which is being experimentally used in building back walls and end walls of the open-hearth furnace, and the natural diatomaceous earth blocks used as a thermal insulator on heating furnaces. In these instances, however, the manufacturing processes are simple, consisting mainly of a mechanical shaping of the blocks. On the other hand, where brick and special shapes of exact dimensions must be used, and where permanent changes in shape and dimensions are undesirable, as they are in the complicated structure of a by-product coke oven or the arched roof of an open-hearth furnace, the maker of refractories finds it advisable to use high temperature. We might rationalize it on the general principle that it is well to subject a product in the course of its manufacture to conditions similar to those it will have to meet in service. This is particularly true of fire clay, magnesite, chrome ore, and of silica in many of its applications. These materials undergo changes at high temperature whose effects it is desirable to anticipate and forestall.

* The Edward Orton, Jr., Memorial Lecture, delivered at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 23, 1937. Received December 13, 1937.

[1] J. B. Johnson, "Thermal Agitation of Electricity in Conductors," *Phys. Rev.*, **32**, 97–109 (1928).

IV. The Pyrometric Cone

The desirability of measuring temperature in the ceramic arts was early recognized. It did not take the primitive clayworker long to find out that there is such a thing as too hot a fire for his ware. The natural thing was to judge the temperature by the brightness or by the color of the hot object, but it was soon learned that "a white heat" never meant the same thing to two men, nor to the same man twice. Wedgwood, the English potter, was the first (about 1780) to propose a quantitative measure for high temperature in the ceramic arts. He placed in the space whose temperature was to be determined a cylinder of clay of definite size, removed it after a definite interval of time, and measured its shrinkage by means of a graduated wedge. This gave him a number which identified the temperature that had been attained and served as an aid in reproducing it.

During the next hundred years physicists were busy making pyrometers that utilized a great variety of properties, for it is obvious that any property whatever which is a continuous and single-valued function of temperature can be used to measure temperature. They tried reversible expansion, electrical resistance, thermoelectric force, brightness of visible radiation, heat capacity. One group of properties that they neglected was the flow characteristics (fluidity and plasticity) of viscous liquids. Almost exactly one hundred years after Wedgwood came Seger, the German ceramist, with his invention of what is now known as the "pyrometric cone."* This device utilizes these facts, *viz.*, (1) the fluidity of a fused silicate increases very rapidly with temperature, and (2) the fluidity is very dependent upon composition. It is therefore possible to make a series of silicate mixtures each of which flows rapidly within a characteristic narrow span of temperature. Made up into little cones or sharp-pointed pyramids and set at a slight inclination, these silicate mixtures bend gracefully at fairly definite temperatures, until the tip comes down level with the base.

Seger based the composition of his first series of cones upon a totally irrelevant series of molecular formulas. We can perhaps understand his reason for this when we realize that molecular formulas in chemistry were just then much to the fore, thanks to the rapid development of organic syntheses, while the principles of phase equilibrium and the existence of eutectic mixtures in polycomponent systems were only imperfectly understood. Seger's series proved unsatisfactory in that its intervals were unequal, certain of the numbered cones coming down almost simultaneously. Furthermore, the methods of blending and preparing the cone materials were not sufficiently standardized to secure uniform and reproducible results.

As the Edward Orton, Jr., Memorial Lecturer for 1937, I have the national pride and the professional satisfaction of being able to point now to one of Professor Orton's greatest services to ceramic industry, namely, his work in improving and standardizing the pyrometric cone series.[2] Probably the men best qualified to perceive what this work must have involved are those scientists in the Bureau of Standards who have had the care of the Bureau's well-known standard samples. It is no small task to guarantee to supply, year in and year out, a manufactured product whose qualities never vary. Most manufacturers will not even attempt so difficult a task; in fact, the progressive manufacturer must aim at just the opposite thing, a product that changes from year to year in any direction that the purchaser will consider to be an improvement. Ably seconded by our fellow member in the Society, H. B. Henderson, Professor Orton established his cone manufacturing business on a basis of "quality first," and saw it handsomely maintain itself because of the immediate response of users to a product of reliable and constant quality.

It was a mark of high confidence in his associates when Professor Orton bequeathed his cone factory to a Research Foundation in whose management the American Ceramic Society has a predominating influence. If the Foundation proves equal to its opportunity and responsibility, its suc-

* The idea of a graded series of silicate mixtures as indicators of temperature appears to have originated with Lauth and Vogt, at the French porcelain works at Sèvres, but Lauth and Vogt depended upon the sudden fusion and disappearance from view of successive members of this series, differentiated by being made up into various geometric forms. They appear to have been satisfied to use the device in crude form within their own plant, without attempting to improve it for the benefit of the ceramic industry.

[2] The pyrometric cone was first made and used in America by one of our Charter Members, Karl Langenbeck, in 1887.

cess will interest a wider circle than just the ceramic industry, for it will furnish a partial answer to those who ask dubiously: Can any business operate successfully without the incentive of private profit? The acceptance of a going manufacturing concern as a kind of legal ward of a technical society is a very unusual thing, and we shall do well to remind ourselves periodically of our unique position in this respect.

It must be emphasized that the pyrometric cone is not a true pyrometer, for its bending does not depend upon temperature alone but also upon the time interval during which it has been exposed to a given temperature. It is best not viewed as an individual indicator or pyroscope, but always as a member of a series. When we heat a set of pyrometric cones at a steadily rising temperature, what we actually observe is a series of time intervals which are also temperature intervals, between the bending of successively higher numbers in the set. The important thing, therefore, is the interval, and not the absolute magnitude, of the temperature.

So successful have pyrometric cones been in the control of the manufacture of refractories that true pyrometers have found relatively little use in that industry. One reason has been the inaccessibility of the middle of the setting in a fixed kiln, or the middle of a car of brick in a tunnel kiln. If a thermoelectric pyrometer were desired, many feet of thermocouple wire would have to be run and a long protection-tube used, and the difficulties of placing such a tube in the midst of a setting are easily imagined. A thermocouple on a moving car is not very practical because of the necessity for electrical contacts. Again, the temperature is usually so high that only platinum thermocouples can be used, and long platinum couples are expensive. A total-radiation pyrometer can be sighted into the setting, but it has a cone of vision of appreciable angle and can not be sighted on an area of a few square inches at a distance of eight or ten feet, as would be necessary if we wished to read the temperature far back among the brick and not be misled by the relatively large effect of nearby surfaces. There remains the optical pyrometer, which is capable of measuring accurately the temperature of very small and very distant objects, but it requires always the individual judgment of an observer and makes no automatic or continuous record. The latter is true also, to be sure, of the pyrometric cone, but the cone stays on the job and begins its cycle of reactions when its temperature is reached, whether the observer be on hand or not. Hence from the stage of bending of a group of cones, placed in the midst of the setting and observed through a narrow channel between the brick or the saggers or the pieces of ware in a kiln, an experienced fireman can make a close estimate of the course of events just preceding his observation.

V. Temperature and the Use of Refractories

Having made and sold his refractories, often without knowing or caring what was the actual temperature to which they have been fired even though they were under close pyrometric control by means of cones, the manufacturer must leave them to their fate at the hands of the operator of a furnace in a steel plant. This individual is a forthright person, six feet two inches, 190 pounds, who can throw a shovel full of wet chrome ore through the furnace door and across twenty feet of hearth, and place it accurately in a small hole in the back wall of an open-hearth furnace at the hottest stage of the furnace cycle just after tapping, in the late afternoon of a day in mid-July. He has a justifiable pride in his proficiency in a calling that demands a maximum combination of physical endurance and seasoned judgment. Three decades ago this individual looked upon the delicate mechanism of a galvanometer as something in a class with a humming-bird or a lady's slipper, completely out of place in the clanging, rumbling open-hearth shop, and as little worthy of respect as the cigaret-smoking chemist had been a quarter of a century earlier. The best pyrometer for the open-hearth was the human eye, aided by the familiar blue glasses and by a happy accident of the physiological optics of color, the discussion of which must be postponed to some other occasion. Whether or not the furnace was dangerously near the temperature of failure of its refractories could only be judged by the eye, and let no one assume that the trained eye is not a good pyrometer. For many years it has put to shame the numerous devices that optimistic physicists have put forward to replace it. But, unfortunately, optic nerves and brain do become fatigued, and they suffer from the hangover that follows the robust indulgences of a man of good basal metabolism. More unfortunately still, the operator has more pressing things to do than to stand with his eye glued to the roof or walls of his fur-

nace, and things may happen when he is not looking, things that happen fast when two-thirds of a million British thermal units per minute are being pumped into a furnace.

The foundation of fact beneath these distressing failures of furnace roof or walls is simple. The open-hearth roof is built of nearly pure silica. As shown graphically in Fig. 1, the silica molecule, though satisfied at ordinary temperatures with the trigonal trapezohedral symmetry of quartz or rock crystal, its common and nearly universal form, swings to the simpler hexagonal form of tridymite at 870°C, and finally relaxes into the isometric modification of cristobalite at 1470°C. Because it undergoes a considerable increase in volume during these transformations, a silica brick is usually fired for several days at a temperature, judged by pyrometric cones, that completes its conversion into cristobalite and tridymite. At 1728°C (3142° F) cristobalite melts. This accurately defined temperature is an inexorable dead-line for the silica roof of the furnace. Mr. Micawber advised his young friend: "Annual income twenty pounds, annual expenditure nineteen nineteen six, result happiness. Annual income twenty pounds, annual expenditure twenty ought and six, result,

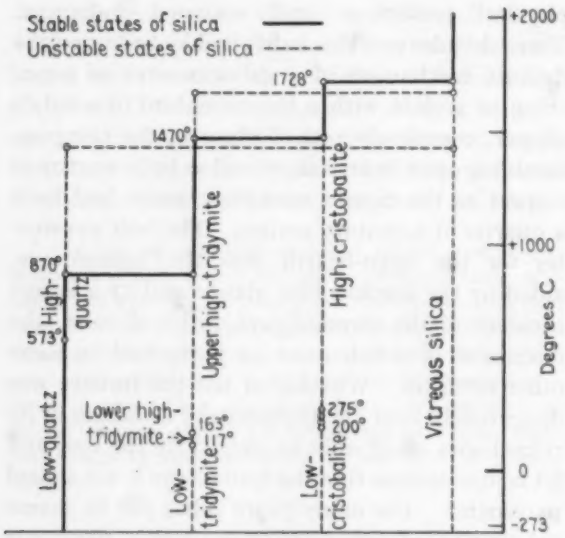

FIG. 1.

misery." Paraphrase this good quantitative advice for the open-hearth operator and we have "Melting-point 1728°, working temperature 1727°, result efficiency and long life. Melting point 1728°, working temperature 1729°, result melting, flow, collapse, five thousand dollars' worth of good steel turned into scrap."

Such would be the situation if the silica roof were actually pure silica and remained so. But a complicating factor now appears. Iron and its oxides have characteristic vapor pressures that rise rapidly with temperature. At 1600°C the vapor pressure of liquid iron is about 0.1 millimeter which means that about 0.1 pound of gaseous iron would be present in the space above the slag and bath if the combustion gases remained there long enough to become saturated. In the presence of the excess of oxygen in the gases, the vaporized iron is subject to oxidation, and it is also likely that oxides such as FeO and Fe_2O_3 themselves have a significant vapor pressure. Now the vapor pressure of a substance in solution is, in general, less than its vapor pressure in the pure state. Consequently the vapor pressure of iron and iron oxide above a ferrous-silicate liquid is lower than the vapor pressure of the pure metal and of its oxides. Result: a liquid oxide of iron condenses on the inner surface of the roof, at the same time dissolving a little silica from the brick and becoming saturated therewith. The process is completely analogous to the absorption of water-vapor from the air by calcium chloride to form a saturated solution, with silica taking the place of calcium chloride and vaporized iron oxide taking the place of water-vapor.

If this liquid were in equilibrium with metallic iron, the iron oxide would be almost entirely in the ferrous state, represented by the formula, FeO, and the equilibrium in the system as a whole[3] would be very nearly as represented in Fig. 2. Our assumed temperature of 1600°C is represented in Fig. 2 by a horizontal dashed line, and the composition of the ferrous-silicate liquid by the point, *a*, about 52% FeO, 48% SiO_2.

Even in contact with metallic iron, however, the silicate liquid is not entirely ferrous, but contains a small proportion of ferric iron, represented by the formula Fe_2O_3. This complication brings us into the three-component system Fe–O–SiO_2, usually written and diagrammed, when we are dealing with the oxide systems, as FeO–Fe_2O_3–SiO_2. This system is represented in the incom-

[3] N. L. Bowen and J. F. Schairer, *Amer. Jour. Sci.*, **24**, 177–213 (1932).

I have revised the temperatures in this and other Geophysical Laboratory papers in accordance with the International Temperature Scale. See R. B. Sosman, *Jour. Amer. Ceram. Soc.*, **16** [1] 63 (1933).

plete ternary diagram[3] of Fig. 3. Our melt clinging to the roof brick may be represented by a point such as *c*.

Next suppose the liquid to be no longer in equilibrium with metallic iron, but to be in contact with a gas containing a small proportion of oxygen. This is the situation in the open-hearth roof. The proportion of ferric iron in the liquid

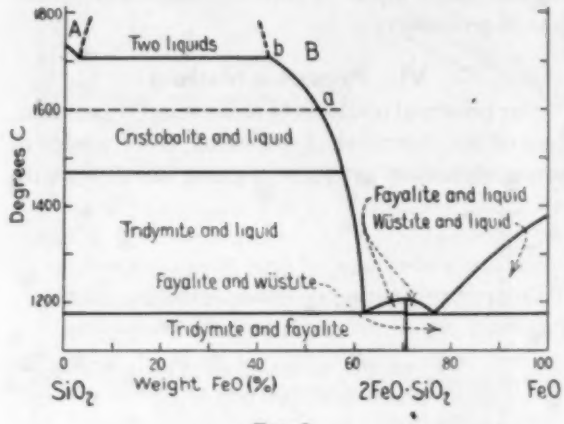

FIG. 2.

will increase, and the composition in our system will be represented by a point in the three-component system FeO–Fe_2O_3–SiO_2 (Fig. 3). Complete data are not yet available to represent the equilibrium state of this system, but we may assume for purposes of description of the phenomena that the composition of the liquid is at *d*, the temperature of the furnace still remaining at 1600°C.

We are now interested to know what will happen if we push up the temperature of the furnace, aiming for that previously mentioned dead-line of 1728°C. To understand clearly what happens, revert to Fig. 2. As the temperature rises, with the amount of iron oxide left unchanged, silica dissolves in the liquid and the changing composition of the liquid is represented by the curve, *ab*. At *b* the temperature is 1705°C and the composition of the liquid is 41% FeO, 1% Fe_2O_3, and 58% silica. At this temperature a new phenomenon intervenes, namely, liquid immiscibility. The silica, instead of dissolving in the liquid already present, melts completely with absorption of just a small proportion of iron oxide, and we then have two liquids, one rich in silica and the other low in silica, both existing side by side but immiscible, like kerosene and water. If the temperature be held at 1705°, the amount of siliceous liquid of the phase *A* increases, while the amount of iron-rich liquid (phase *B*) decreases because it is furnishing iron oxide for phase *A*, which contains 97% silica and only 3% FeO. The final result is almost complete liquefaction of the silica at 1705° (3101°F).

Now go back to Fig. 3. As the temperature of the furnace is raised, silica dissolves just as it did on the line *ab* in Fig. 2, but the amount dissolved is small and the roof is not endangered. At point *e*, however, we reach a temperature of formation of two liquids, analogous to point *b* of Fig. 2. This time the silica-rich liquid is represented by a point on the short line bounding the triangle *A* at the SiO_2 corner. The liquid is still almost entirely silica, with perhaps 4% of mixed ferrous and ferric oxides. Its formation, as before, must be accompanied by almost complete fusion of the silica brick. This critical temperature depends upon the position of point *d* (Fig. 3), which in turn is dependent upon the oxidizing power of the gas with which the iron oxides have been in contact. The temperature therefore can not be stated with extreme precision, but we know that it will be lower than 1705°, which is the temperature of approximate binary immiscibility, and it will be higher than 1675°.[4] Observations with thermocouples and optical pyrometers on open-hearth roofs[5] place the fusion temperature at 1650 ± 10°C (3000 ± 20°F). This is about 30° to 40° lower than the expected figure simply because we have not taken account of other oxides present in the brick, particularly Al_2O_3, Na_2O, and K_2O, small amounts of which are effective in further lowering the temperature of fusion.

This limit of 1650° to 1690°C (3000° to 3090°F) is just as much a dead-line for the iron oxide-bearing roof as the original melting point at 1728° was for the pure silica roof. It is lower than that dead-line principally because of the presence of ferrous and ferric oxides, but it can not be exceeded without bringing about complete fusion or collapse of the roof.

Observe now the dilemma of the furnace operator, illustrated by the temperature diagram of Fig. 4. He must at all costs keep his roof below 1650°. But the melting point of pure iron

[4] J. W. Greig, *Amer. Jour. Sci.*, **14**, 474(1927).

[5] Larsen, Schroeder, Bauer, and Campbell, "Service Conditions of Refractories for Open-Hearth Steel Furnaces," *Carnegie Inst. Tech., U. S. Bur. Mines, Min. & Met. Invest. Bull.*, No. 23, 1925. The published data have been corrected to the present International Scale.

(soft steel) is 1535° (2795°F), and he must at all costs keep his bath of 100 to 150 tons of metal up to the melting point. Furthermore, he must make some provision for tapping his steel out of

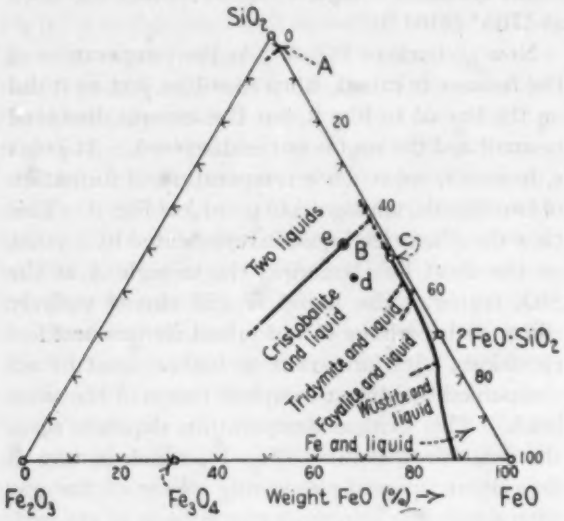

FIG. 3.

the furnace into a cold brick-lined ladle, from which it is later to be poured into molds, a series of operations which will cause it to fall in temperature by as much as 50°C. In the furnace it must therefore have a temperature of at least 1585°. His practical working range near the end of the process, the gradient by means of which he must force up the temperature of the metal by forcing down the temperature of flame and roof, may consequently be less than 65°, often not more than 50°. The ancient mariner navigating his ship between the rock of Scylla and the whirlpool of Charybdis could have sympathized heartily with the modern open-hearth melter.

It is easy to understand how the melter, striving to keep up his tonnage rate to the maximum of which his furnace is capable, will keep his roof as near as he dares to the dead-line of 1650° because every degree counts. Yet he must be wary, for any tell-tale icicles[6] of fused silica that show the roof to have been temporarily overheated will go down as a black mark against his record. It required no search on the part of the organizers of the research laboratory of a steel-making corporation to see that here was a pyrometric problem whose solution would be of value to the industry.

It is a satisfaction to record that through the inventiveness and experimental skill of B. M. Larsen, W. E. Shenk, and Lewis Rumford, II, members of the Research Laboratory with which the lecturer is connected, and through the experienced assistance of many in the plants of the Corporation of which this Laboratory is a part[7] we now have a satisfactory solution to this pyrometric problem. Before describing how it works, let me revert again to some fundamental principles of pyrometry.

VI. Pyrometric Methods

Our principal methods of measuring the temperature of hot objects are typified by three modes of sense impression, *viz.*, (1) touching the object with

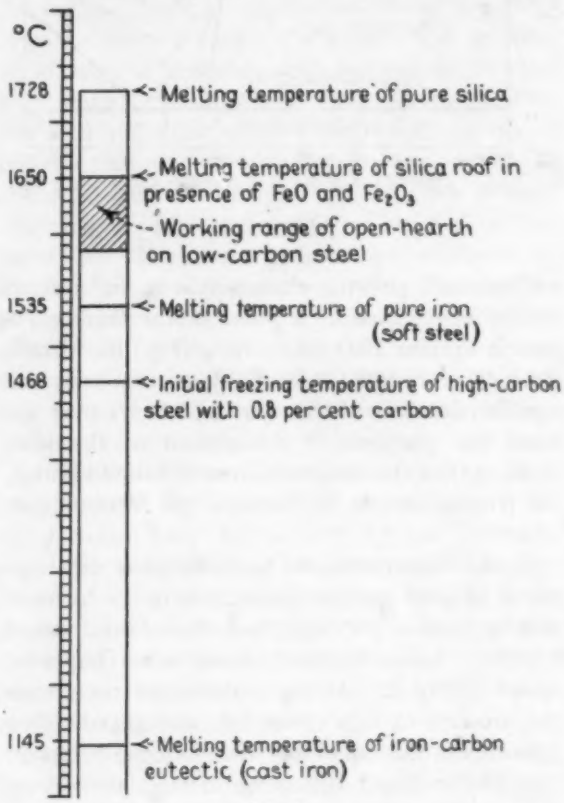
°C
1728
Melting temperature of pure silica
1650
Melting temperature of silica roof in presence of FeO and Fe_2O_3
Working range of open-hearth on low-carbon steel
1535
Melting temperature of pure iron (soft steel)
1468
Initial freezing temperature of high-carbon steel with 0.8 per cent carbon
1145
Melting temperature of iron-carbon eutectic (cast iron)

FIG. 4.

the hand, (2) holding the hand or cheek near the object to feel its radiated warmth, and (3) looking at the object to see how bright it appears.

[6] Dr. Austin would call them "silicicles."

[7] I wish especially to mention, in recognition of direct assistance and suggestions received, Matt Phillips of Worcester, Chester Siddall of Pencoyd, V. Gregor and Carl Oseland of Gary, W. C. Hogg, T. C. King, J. McGill, and B. B. Bargman of Homestead, J. F. Perkins of South Chicago, L. A. Kline of Ohio, R. Merk of Farrell, L. A. Terry of Lorain, P. Bowron and R. H. Cantrell of Ensley and Fairfield.

The thermoelectric pyrometer is the most commonly used "touch" pyrometer. A thermocouple is placed in direct contact with the object and assumes its temperature. The electromotive force

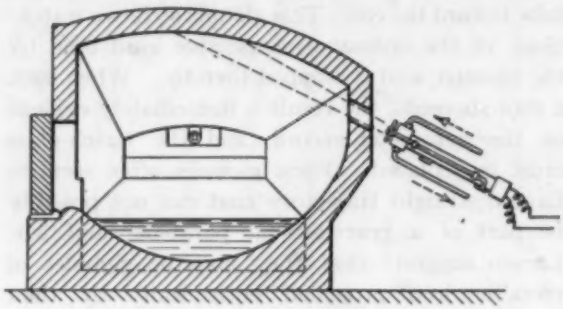

FIG. 5.

of the couple is then read by means of a millivoltmeter or a potentiometer.

The total-radiation pyrometer is the principal pyrometer of class (2), depending upon feeling without touching. It receives all the radiant energy from a defined portion of the surface of the object, and absorbs it in a thermoelement which is thereby warmed above the temperature of its surroundings.

In class (2) are other pyrometers which are partial-radiation instruments, that is, they do not absorb the whole energy but only that portion which falls within certain limits of wave-length. Several kinds of photoelectric pyrometers are included here. One utilizes the vacuum photoelectric cell, which absorbs part of the visible radiation and part of the infra-red or heat radiation near the visible. When absorbed in the sensitive surface, these radiations release electrons, and a voltage applied to the photoelectric cell sets these electrons into directed motion and so produces a current that can be measured. Another utilizes the self-generative photoelectric cell, of which the best-known example is the Photronic cell of the Weston Electrical Instrument Company. This cell has a sensitivity curve similar to that of the human eye and is little affected by the infra-red. The light absorbed by the cell surface is converted directly into an electric current which can be sent through a measuring instrument and which is but little influenced in magnitude by the resistance of the circuit.

Totally different, though often classed as a "partial radiation" instrument, is the optical pyrometer, which I have put in a third class and have associated with "looking" as contrasted with "feeling" and "touching." To the optical pyrometer the area viewed and the distance of the object are of no importance, for the quality measured is the intrinsic brightness of the surface and not the energy radiated thereby.

VII. Pyrometry of the Open-Hearth Roof

After trying in the open-hearth roof many of the various applications of the pyrometric methods just outlined, we have settled upon two as most satisfactory, namely, the total-radiation pyrometer and one of the partial-radiation instruments.

The temperature that we want is the temperature of the inner surface of the brick. This is the place where the temperature changes most rapidly with changing flame conditions and where damage is done in the shortest time. A pyrometer that receives the radiation directly from the inner surface is therefore the ideal.

It has proved satisfactory to sight the pyrometer through an opening in the back wall of the furnace, directing it upward toward the roof, while keeping a position such that it will not receive direct radiation from a flame. Figure 5 is a cross-

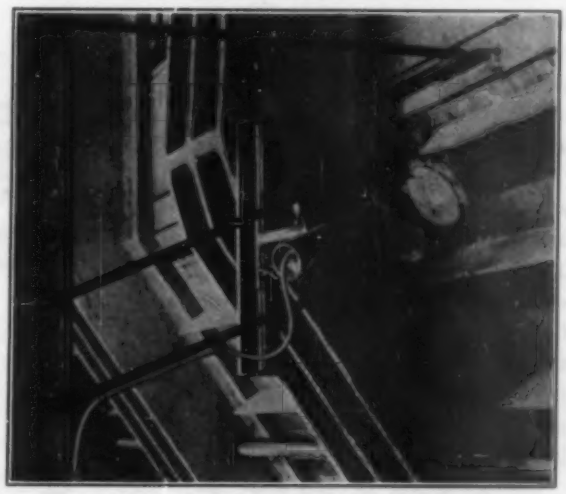

FIG. 6.

section (not drawn to scale) of the furnace showing the position of the pyrometer in relation to back wall and roof.[8] Figure 6 is a photograph of such an installation.

Both the total-radiation and the photoelectric pyrometers need protection against the high tem-

[8] From Hogg, King, and Rumford, U. S. Patent 2,056,672, Oct. 6, 1936.

peratures prevailing near the furnace. The protection used with the total-radiation pyrometer[8] is shown in Fig. 7. Under most circumstances only the end exposed to furnace radiation needs

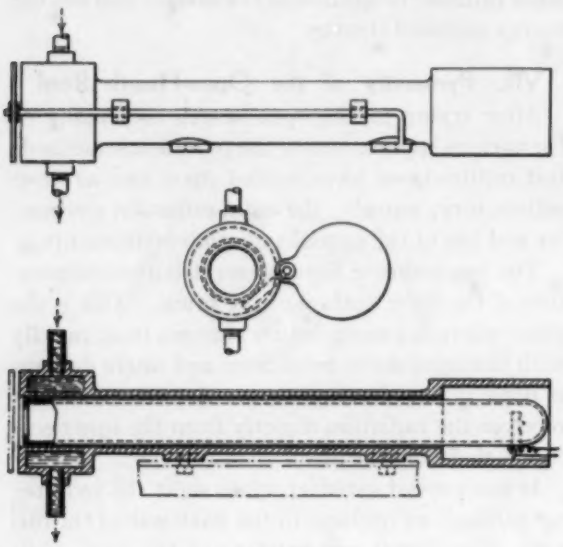

FIG. 7.

to be protected by water-cooling. The instrument itself will stand a temperature of over 100°C without damage, and it is better to keep it warm than cold, because condensation of moisture, especially in summer, is prevented if the tube is warmer than the air.

The photoelectric cell is more sensitive to rising temperature and must be kept below 30°C. This demands a more complete water-jacket than is needed for the radiation tube, because considerable radiation reaches the pyrometer during the tapping period. The jacket used is shown[9] in Fig. 8.

Condensation of moisture in the tube is prevented by passing a current of clean warm air into the water-jacket, past the cell, and out through the open end toward the furnace.

In both pyrometers, flying particles of slag or iron oxide must be guarded against. Most such particles have a curved trajectory and are caught by one of the diaphragms shown in Fig. 8, but it is astonishing to see the occasional accuracy of aim of the Satanic Jinx who presides over such furnaces. Every few months he succeeds in shooting a fiery globule straight down the axis of the tube toward the cell. This globule strikes a watch-glass, of the ordinary inexpensive kind used by the chemist, and is stopped thereby. When such a shot succeeds, the result is immediately evident on the pyrometer record, and the watch-glass must be replaced. These globules often seem to have a straight trajectory that can not possibly be part of a gravitational parabola, and Mr. Larsen suggests that they may be globules of metallic iron propelled horizontally by their vigorous oxidation in the furnace atmosphere; they are properly classed as rockets rather than projectiles.

The temperature record is made by an automatic potentiometer. When used with the radiation pyrometer, the potentiometer measures the electromotive force of the absorbing thermocouple in the radiation tube. When used with the self-generative photoelectric cell, the potentiometer records the electromotive force across a fixed resistance in series with the cell. In both cases, the calibration is done directly in the furnace itself by means of an optical pyrometer

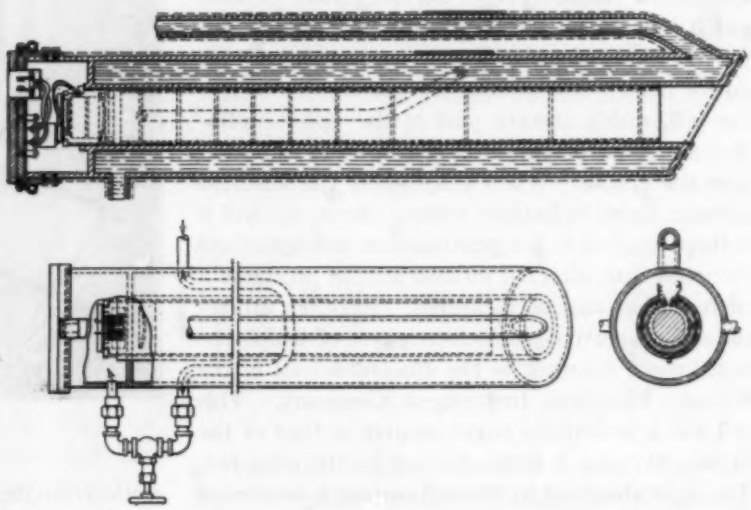

FIG. 8.

which in turn has been compared with a standard of brightness furnished and annually verified by the Research Laboratory at Kearny. In this way we can be sure that all plants are reading on the same temperature scale, and the experience

[9] B. M. Larsen and W. E. Shenk, U. S. Patent 2,054,382, Sept. 15, 1936.

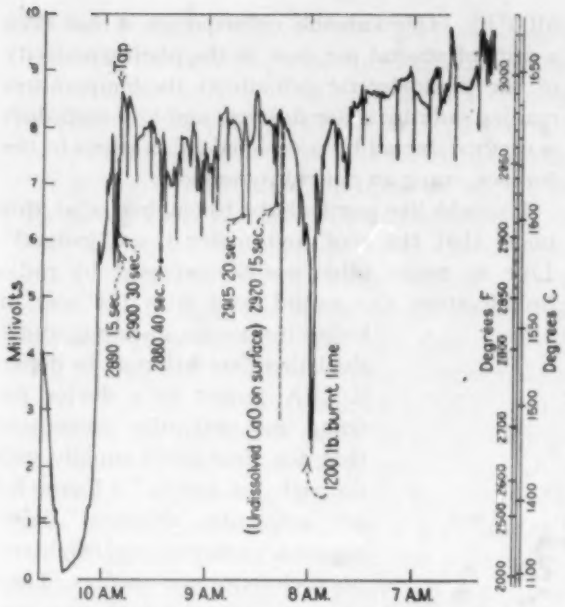

FIG. 9.—Strip chart record of roof temperature by photoelectric pyrometer. Heat 10–112 (Pencoyd Works). Points specially labeled are temperatures obtained by permitting roof and slag to equalize by radiation, with fuel off.

of one plant can be confidently compared with that of another.

The automatic potentiometer records are of two types, strip-chart and circular-chart. Figure 9 is a portion of a strip-chart record of a photoelectric roof pyrometer, traced and re-lettered for reproduction. The scale of the chart is a standard 100-millivolt scale, and the conversion into degrees is shown by the double scale at the side of the figure.

Figures 10 and 11 are tracings of complete circular-chart records of a photoelectric and a radiation pyrometer, respectively. The scales are direct, in degrees Fahrenheit.

Every pyrometrist knows that an optical pyrometer reading taken in an open-hearth furnace while there is flame in the furnace gives a false temperature, because of the reflection from the glazed roof and walls and from the liquid slag. The true temperature can be obtained only at the moment of reversal of the furnace. This fact is illustrated in all three of the records in Figs. 9 to 11. The short vertical lines extending downward from the main portion of the record would end in the true temperature of the roof if they could be made instantaneously or if the temperature of roof, slag, and walls were uniform. In the later stages of the heat, they do come fairly near recording the true roof temperature. It is not necessary, however, to record the true temperature, because experience fortunately shows that with a given furnace and fuel the difference between the true and the apparent temperatures of the roof is reasonably constant. The apparent temperature with flame on is therefore quite satisfactory as a basis of control.

The nominal temperature for automatic control of the fuel is best determined for each furnace by actual trial. It nearly always happens that the operator, with remembrance of burned roofs from his past experience, will tend to "play safe" and set the control to hold the roof about where he would hold it in his accustomed method of working. Occasionally, on the other hand, some one will assume that the new instrument is capable of defying the laws of Nature and will set the control too high. It is possible to see in a few hours where it is best

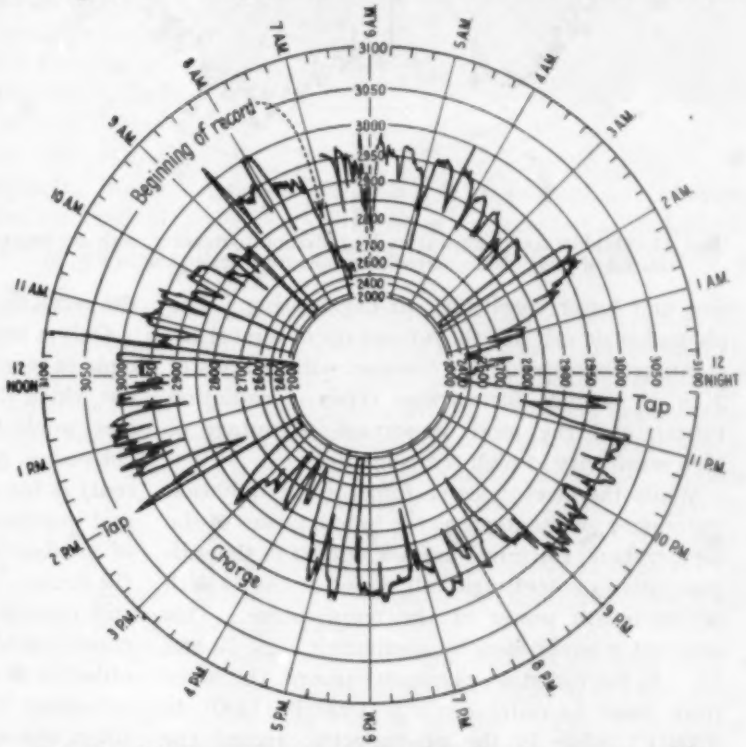

FIG. 10.—Middle roof temperature by photoelectric pyrometer, with automatic control of fuel.

to set the control for the most efficient operation. If the point differs appreciably from that already found for similar furnaces and fuels, there is ground for study of the conditions of combustion and the distribution of temperature in the furnace.

It is not yet possible to make a reasoned choice between the radiation and photoelectric pyrometers for purposes of roof control. Mention has already been made of the advantages that the radiation tube possesses by virtue of its smaller size and lower sensitivity to overheating. The photoelectric cell has the advantage of almost instantaneous response (in contrast with periods of 2 to 15 seconds for various types of radiation tubes), and the more important advantage of high sensitivity at high temperatures.

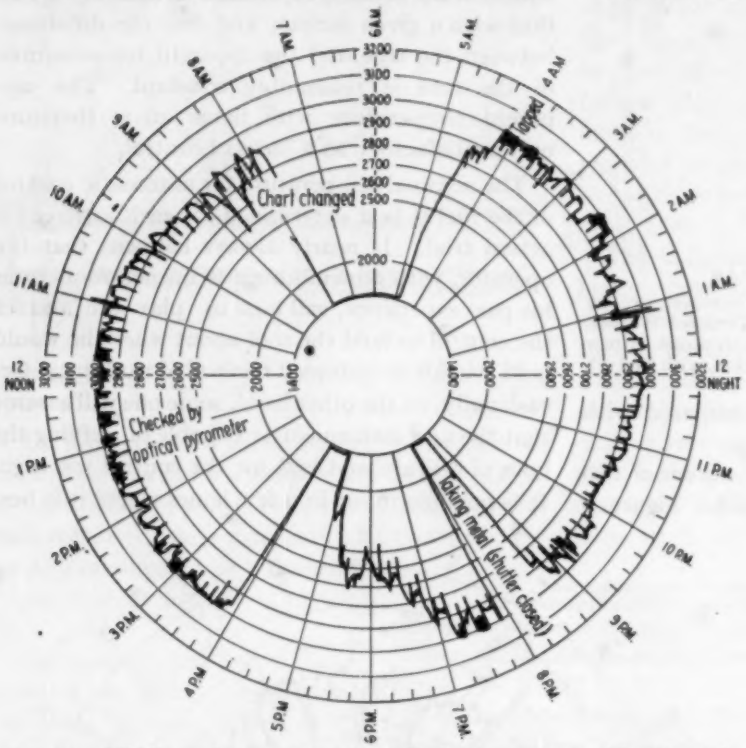

FIG. 11.—Middle roof temperature by radiation pyrometer, with automatic control of fuel. Note narrower temperature scale than in Fig. 10.

While the electromotive force of the radiation pyrometer varies about as the fourth power of the temperature, the micro-ampere output of the self-generative photoelectric cell varies as the twelfth or thirteenth power of the temperature. This contrast is easily seen by comparing Figs. 10 and 11. In the radiation pyrometer record, the range from inner to outer circle is 1800°F (1400° to 3200°F), while in the photoelectric record the same radial distance is only 1100°F (2000° to 3100°F). One valuable consequence is that even a drift of several per cent in the photosensitivity of the photoelectric cell affects its temperature reading only by a few degrees, and any such drift is easily detected by occasional calibrations in the furnace, using an optical pyrometer.

I should like particularly to emphasize at this point that the roof pyrometer is no "gadget." Like so many other words over-used by radio broadcasters, this useful word is in the way of losing its precise meaning, and I shall therefore attempt to define it: "A gadget is a device for doing automatically something that the user could equally well do with his hands." Examples are automatic electrical toast-poppers, catalytic cigar-lighters, photoelectric door-openers. They are convenient, useful, unnecessary. The roof pyrometer is not in this class. It tirelessly watches the temperature of the roof every moment of the twenty-four hours, and instantly throws on or off a part of the fuel whenever the temperature falls or rises a few degrees, a service that no human being could perform faithfully for more than a few minutes at a stretch.

VIII. Regenerator Pyrometry

Another pyrometric application in the open hearth that preserves and lengthens the life of the refractories is pyrometry of the regenerators.

Only a few words are needed to recall the principle of regeneration, invented by Siemens, without which the open-hearth furnace as a melter of steel would be ineffective. The fuel (natural gas, coke-oven gas, oil, tar, producer-gas, powdered coal) is burned above the hearth of the furnace and radiates to the melting steel. The products of combustion necessarily leave the furnace at the furnace temperature of 1550°C or more, while still capable of heating a colder object through a considerable range of temperature. This colder object is provided in the form of a checkerwork of refractory brick, usually fire clay but sometimes silica, chrome, or magnesite, built up inside a regenerator chamber or chambers. After a period

of ten to twenty minutes, the fuel is reversed in direction through the furnace and the air supplied for combustion is sent through the hot checkerwork, becoming preheated thereby, while the products of combustion are now sent through a similar checkerwork of brick at the opposite end of the furnace. This cycle is repeated indefinitely.

If heated to the temperature of the outgoing gases, the fireclay brick of the checkers would soften and collapse, and the iron oxide always present in the gases would flux the brick down to a thin slag flowing to the bottom of the regenerator chambers. Furthermore, maximum efficiency in utilization of the fuel requires that the period between reversals and the consequent range of temperature change be neither too short nor too long. For these and various other reasons, it is evident that improvements in the design of the regenerators must be preceded both by theoretical and experimental knowledge of the effects of different distribution of temperature within the checkerwork. The temperature of the checkerwork is therefore the controlling variable.

The problem of regenerator pyrometry is similar in many ways to that of roof pyrometry, but with complications of its own. Much has been and is being done by means of thermocouples, inside of protection tubes, inserted into the gas spaces and flues. The hot end of the checkers, however, is too hot for the use of inexpensive base-metal couples, and platinum couples are subject to contamination and destruction by the ever-present oxide of iron. Thermocouple pyrometry in the regenerators, consequently, has been confined to the cooler parts of the regenerators and to the flues and the waste-heat boiler systems.

The electromotive force of a thermocouple in such a position is a complex resultant. The couple is warmed or cooled by the gas that sweeps past it, it is cooled or warmed by radiation to or from all the walls and brick within sight of its junction, and it is cooled by conduction along its own wires. The resulting temperature of the junction is the temperature neither of the gas or air, nor of the checker brick, nor of the wall. It rises and falls with each reversal of the furnace, and thus furnishes a useful empirical guide to furnace operation, but it does not supply the information desired by the engineer or the designer.

For actual brick temperatures at the hot end, we must do as we did with the silica roof and look directly at the surface whose temperature is wanted, using either the radiation or the photoelectric pyrometer. Since the temperatures are appreciably lower than on the roof (1000° to 1450°C or 1800° to 2600°F), the amount of light available for the photoelectric cell is much less than from the roof, and a larger area has to be viewed. A shorter and wider water-jacket is therefore used with the cell in the regenerators. With the radiation pyrometer, either a water-jacket of simple construction is used or no jacket at all. A photograph of a regenerator installation is shown in Fig. 12.

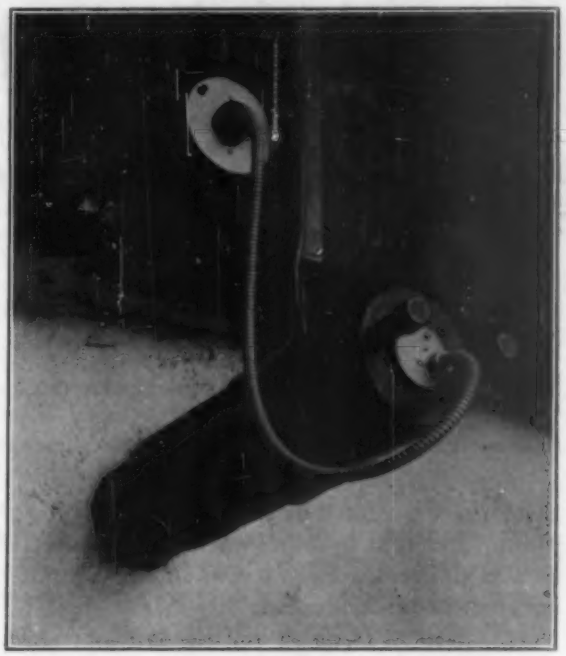

FIG. 12.

Since temperatures are being measured at two points the record is a little more complex than the roof record. A further complication is added if there are two regenerator chambers in parallel at each end of the furnace and temperatures of both are desired in order to guide the operator in the distribution of the waste gases. This is the case when producer gas is used as fuel, for it is desirable to preheat this gas separately from the air, though not to the same temperature to which the air is preheated.

Where only two temperatures are measured, a two-point "pen-dragging" recorder is often used, either with strip or circular chart. This instrument records first the temperature at one end for a fraction of a minute, then draws a nearly straight

line across to the temperature of the other end, and so repeats back and forth. The result is a series of "butterflies" in nearly solid color (see Fig. 13), whose form and position can be inspected from a distance and which are therefore preferred by some operators. A glance at Fig. 13 shows, from the evenness of the butterflies, that the two ends of this furnace were well balanced. Another type of record, preferred by other operators, consists of dots in different colors or rows of small printed numerals in different colors.

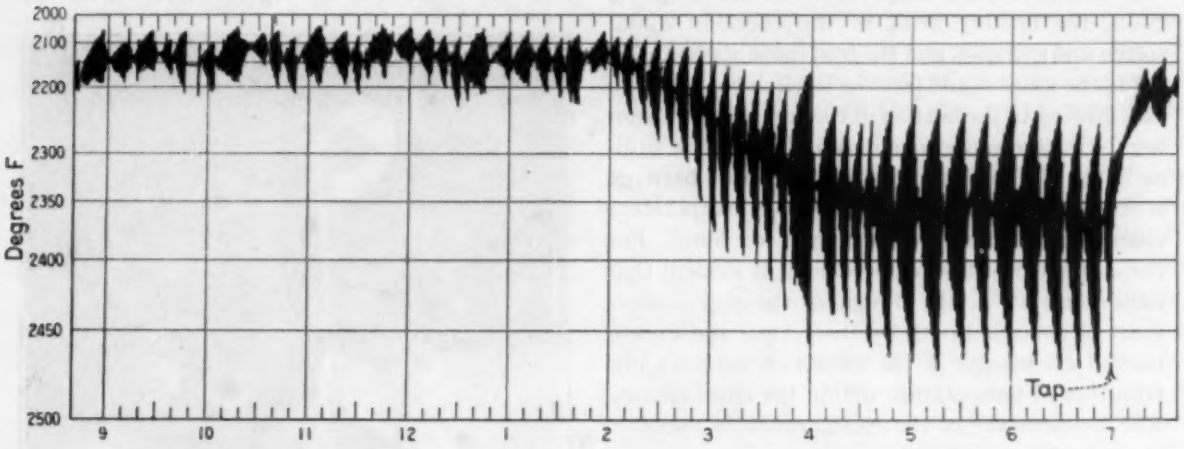

FIG. 13.—Pencoyd furnace No. 9. Top checker brick temperature by Photronic cell and automatic potentiometer.

Automatic reversal of the furnace and automatic control of the proportion of waste gases in two parallel chambers, where this proportion is susceptible to control by means of dampers, are features easily added when satisfactorily accurate temperatures of the hot end are being read.

IX. Value of Open-Hearth Pyrometry

The foregoing discussion of pyrometric methods has, I trust, proved the statement made in my opening paragraph, that an important function of the pyrometer in the steel plant today is the preservation of the open-hearth refractories.

In a well-operated furnace, the average amount dissolved from the interior surface of the silica roof is only a few hundredths of an inch per heat of steel, usually less than a tenth inch per day. A few minutes of overheating, consequently, will do damage equivalent to many heats or many days of normal operation. In preventing such temporary overheating, for which the furnace operator may be in no way to blame, the pyrometer serves as an ever-present insurance.

The regenerator pyrometer likewise acts as a protector and preserver of refractories, sometimes in unexpected ways. An application of regenerator pyrometry that serves to illustrate the value of knowing a temperature instead of inferring it developed only a few weeks ago at one of the Corporation plants. The valve mechanism on one of the two chambers at one end of the furnace accidentally failed, and the valve did not open completely. Consequently the bulk of the waste gas was sent through the other chamber. There was no thermocouple pyrometer in a position to indicate anything abnormal, but the pyrometer sighted on the hot end of the checkers showed by its unusually rapid rise that something was wrong, enabling the operator to shut down temporarily until the valve could be opened, thus saving the threatened checkers from being damaged or melted down. The saving of time and material by this single bit of rescue work more than paid for the pyrometer installation and would have justified the superintendent in calling the expenditure for pyrometers "accident insurance."

Even more important than its service as a protector is the action of the roof pyrometer in maintaining uniformity of operation. The difference between visual-manual control and automatic control of the roof temperature is similar in kind to the difference in efficiency between a hand-operated and a motor-driven grinding wheel.

The effectiveness of pyrometric roof control has been demonstrated in numerous furnaces that have been equipped either with photoelectric or total-radiation roof pyrometers of the type described.

A lengthening of roof life or a saving in fuel with undiminished output has been the usual result. The economic value of roof control is best estimated by the operating men, whose data show that the savings due to such control of temperature amount to a noteworthy annual sum. In such matters, however, the scientist or the technical man has no professional interest; he must obtain his satisfaction in seeing some real improvement come out of his professional labors, let the profits fall where they may.

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Kearny, New Jersey

THE STRUCTURE OF SILICA GLASS BY X-RAY DIFFRACTION STUDIES *

By B. E. Warren and J. Biscoe†

Abstract

Three definite conclusions can be drawn from the X-ray diffraction studies of vitreous silica. (1) The tetrahedral scheme of coördination, in which each silicon is tetrahedrally surrounded by four oxygens and each oxygen shared between two silicons, is given directly by the Fourier analysis. (2) The liquid-like continuity in the structure of glassy silica with no indication of discrete particles is given by the absence of small-angle scattering. (3) If the diffraction pattern is explained by assuming small cristobalite crystals in the glass, calculations are made from the peak breadth that the particles can not be greater than about 8A. The random-network theory of the structure of glass is in agreement with these experimental facts.

I. Introduction

Glass is usually called an undercooled liquid, the name suggesting that, although it has many of the mechanical properties of a true solid, it differs from the crystalline form of matter by not having passed through a sharp or definite transition in solidifying from the melt. As a result of X-ray diffraction studies, two theories of the structure of glass have developed. The *crystallite theory* pictures glass as an agglomerate of extremely small crystals of one or more chemical compounds. The *random-network*, or noncrystalline network, theory pictures the glass as a continuous assemblage of atoms in which there is a definite scheme of coördination and definite interatomic distances but in which no unit of structure repeats itself identically at regular intervals in three dimensions; hence, by definition, it is noncrystalline.

It is well known that the X-ray pattern of an amorphous material, such as a liquid, consists of a few broad diffuse rings, while the powder pattern of a typically crystalline sample shows a large number of sharp rings. From the point of view of the crystallite theory, the broad peaks in the diffraction pattern of vitreous silica are explained by assuming cristobalite crystals so small that the lines of the powder pattern broaden out to give the observed scattering curve.

Except at very small scattering angles, either theory would predict essentially the same experimental scattering curve. Because of this, it is not a simple matter to prove uniquely from the X-ray results that one theory is right and the other wrong. In the critical discussion to follow, it will be shown that the crystallite hypothesis can be maintained only if it is postulated that the majority of the crystallites are so small and so distorted that the use of the term, "crystallite," ceases to have any clear meaning or justification.

The best approach to the problem would be first to ask what information or conclusions there are that can be taken as definite and quite independent of any doubtful assumptions. To deduce crystallinity from a Debye-Scherrer-Hull type of powder pattern really involves assuming it, and the extent to which the assumption is justified depends upon the number of lines on

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* Part of a paper entitled, "X-Ray Diffraction Studies of Silica and Soda-Silica Glass," presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 23, 1937 (Glass Division). Received July 9, 1937.

† Glass Research Fellow. This paper constitutes the first report of work done with the assistance of the Glass Research Fellowship sponsored by eight American glass manufacturers.

the pattern whose positions agree with the line positions calculated for the crystal. The diffraction pattern of vitreous silica shows only a few broad diffuse peaks, but not nearly enough detail to establish crystallinity uniquely.

II. Radial Distribution Obtained from Fourier Analysis

The one quantity which can be obtained uniquely from an X-ray scattering pattern without making any *a priori* assumptions is the radial distribution curve obtained from a Fourier analysis. This method is sufficiently general to apply equally well to a liquid, an amorphous solid, or powdered crystalline material; therefore, in using it, no assumption has been made as to the state of the material. The Fourier analysis of the scattering pattern of vitreous silica has been reported in a previous paper.[1] Figure 1 shows the radial distribution curve which was obtained.

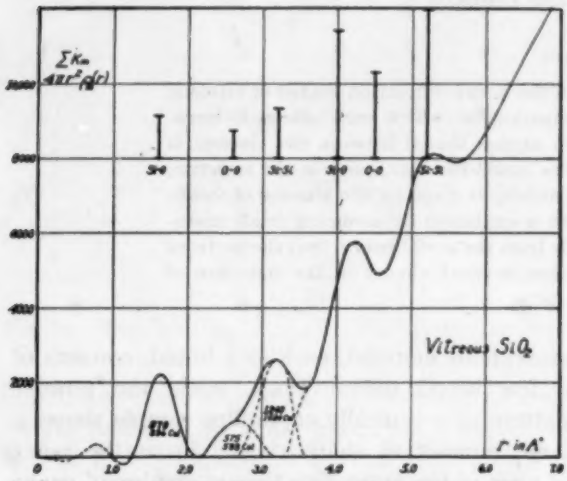

FIG. 1.—Radial distribution curve for vitreous SiO_2.

For a material containing two kinds of atoms, such as SiO_2, the distribution curve really represents two curves superimposed, one giving the distribution of atoms about any silicon and the other the distribution about an oxygen. The different peaks correspond to different interatomic distances in the sample. The position of the peak gives the interatomic distance; the area under the peak gives the number of neighboring atoms at that distance. The particular pair of atoms giving rise to any peak is determined by recognizing known interatomic distances.

The first peak occurs at 1.62A. In the large number of crystalline silicates which have now been analyzed, the silicon is always found to be tetrahedrally surrounded by four oxygens at a distance of about 1.60A. The first peak, therefore, represents the silicon-oxygen neighbors, that is, neighboring oxygens about a silicon and neighboring silicons about an oxygen. From the area under the first peak, 4.3 oxygens are calculated directly about any silicon. Because the silicon is always found tetrahedrally surrounded by four oxygens, this can be taken to indicate 4 oxygen neighbors about each silicon. From the chemical composition, if each silicon is surrounded by 4 oxygens, each oxygen must have 2 silicon neighbors.

If the 4 oxygens about any silicon are tetrahedrally arranged, the oxygen-oxygen distance will be

$$1.62\sqrt{\frac{8}{3}} = 2.65\text{A}.$$

In crystalline silicates the silicon-oxygen tetrahedra share corners but never edges, that is, more than one oxygen is never shared between any two silicons. If this is also the case in vitreous silica, each oxygen should have six oxygen neighbors. An oxygen-oxygen peak at the right position and having the correct area is clearly indicated in the distribution curve although it is not well resolved.

If the two bonds to an oxygen are not far from being diametrically opposite one another, the silicon-silicon distance should be nearly twice the silicon-oxygen distance. The third peak is at about 3.20A, showing that this is the case.

From the Fourier analysis, the fact is evident that in the glass each silicon is tetrahedrally surrounded by four oxygens at a distance of about 1.62A, and each oxygen is shared between two silicons, the two bonds to an oxygen being roughly diametrically opposite. This is the basic coördination scheme in vitreous silica, and can be taken as uniquely established by the Fourier analysis.

This, however, does not answer the specific question as to whether vitreous silica is a random network in which this scheme of coördination exists or whether it is a mass of tiny crystallites.

[1] B. E. Warren, H. Krutter, and O. Morningstar, "Fourier Analysis of X-Ray Patterns of Vitreous SiO_2 and B_2O_3," *Jour. Amer. Ceram. Soc.*, **19** [7] 202–206 (1936).

The tetrahedral coördination scheme, which has been deduced here from the Fourier analysis, is exactly the coördination scheme in tridymite and cristobalite.

III. Comparison of Patterns of Vitreous Silica and Cristobalite

According to the crystallite theory, the diffraction pattern of vitreous silica is assumed to be due to very small cristobalite crystals. Figure 2 shows the patterns of vitreous silica and cristobalite taken under identical conditions. The sample, in each case, was a thin slab of optimum thickness. The cylindrical camera of radius 4.40 centimeters was evacuated to eliminate the air scattering at small angle. The radiation was CuKα (Λ = 1.539A), monochromated by reflection from a rock-salt crystal.

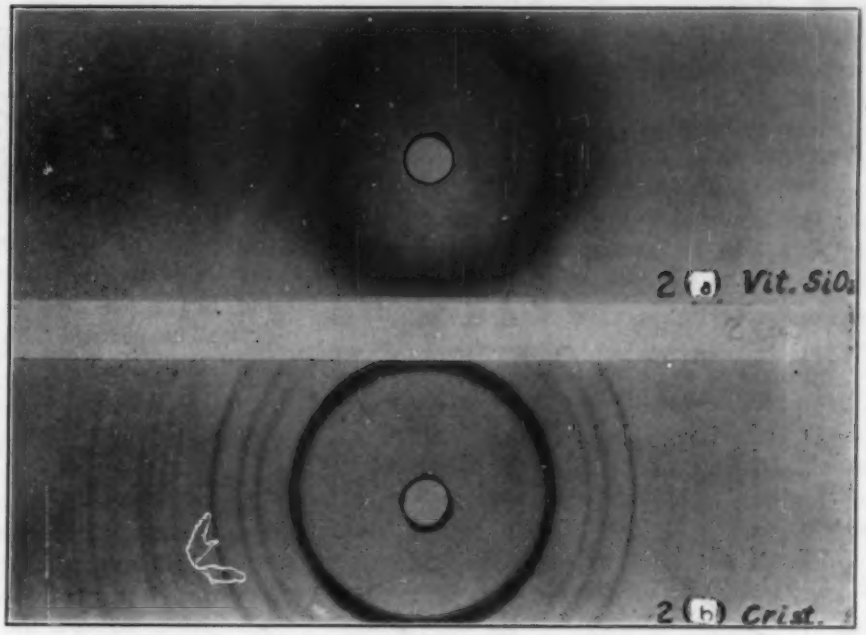

FIG. 2.—X-ray diffraction patterns; (*a*) vitreous silica and (*b*) cristobalite.

Figures 3(*a*) and 3(*b*) show the microphotometer records of the diffraction patterns. The importance of monochromating by crystal reflection and using an evacuated camera is clearly shown in these two records by the absence of extraneous background and the fact that the curves approach zero intensity at small angle. The strongest peak of the cristobalite pattern occurs very nearly at the same position as the main peak of the vitreous silica pattern. With smaller crystals, the sharp peaks would broaden out and, by assuming sufficiently small crystallites of cristobalite, the peaks would broaden out sufficiently so that the strong peak of the crystal would approximate fairly well the broad main peak of vitreous silica. The positions of the two peaks do not agree exactly, but this might be explained by the small size of the crystallites and by possible distortion. From a purely formal standpoint, it might be concluded that the pattern of the glass could be satisfactorily interpreted as due to small crystals of cristobalite.

If it is assumed that glassy silica is an aggregate of small cristobalite crystals, certain conclusions can be drawn. From the powder pattern of a crystal, the average particle size may be calculated from the half-intensity breadth

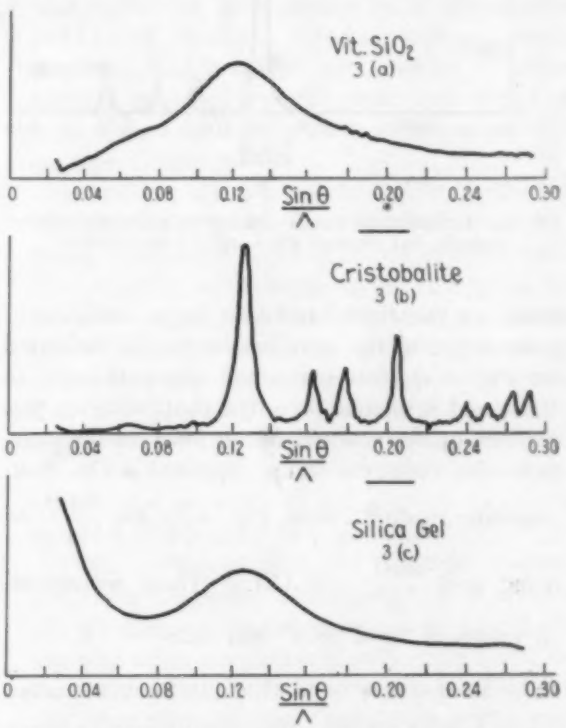

FIG. 3.—Microphotometer records of X-ray diffraction patterns; (*a*) vitreous silica, (*b*) cristobalite, and (*c*) dried commercial silica gel.

of the lines, providing there is a line which will not be overlapped by others. The first line of the cristobalite pattern is so much stronger than the others that it can be safely used for a size determination.

The microphotometer records of Figs. 3(*a*) and 3(*b*) are changed to intensity curves and plotted in Fig. 4. In measuring the half-intensity width of the vitreous silica peak, allowance is

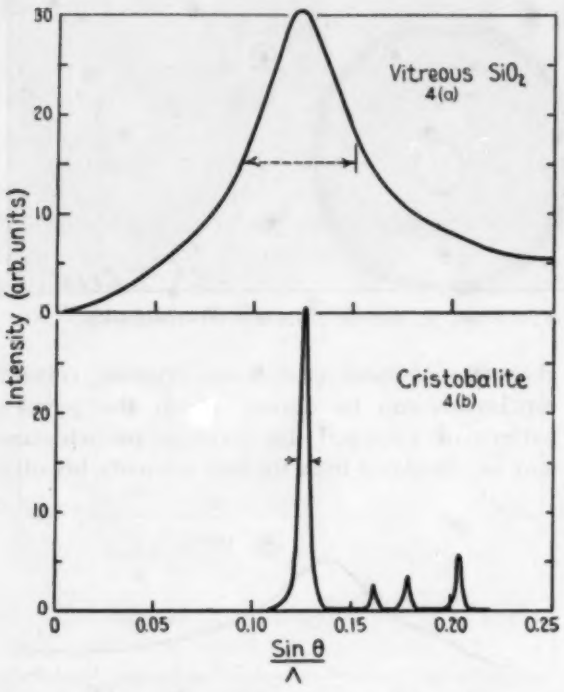

FIG. 4.—Intensity curves obtained from microphotometer records; (*a*) vitreous silica and (*b*) cristobalite.

made on the right-hand side for a small background due to the next few lines. As indicated on Fig. 4(*a*), this correction amounts only to 10%, and it should be noted that, without this correction, there would be an even smaller particle size than the value obtained. The half-intensity readings from Fig. 4(*a*) are $\frac{\sin\theta}{\Lambda} = 0.093$ and $\frac{\sin\theta}{\Lambda} = 0.150$. These correspond to values of 2θ of 16.4° and 26.8°.

$B_m = \Delta(2\theta) = 26.8° - 16.4° = 10.4° = 0.181$ radian.

The measured half-intensity breadth, B_m, must be corrected for broadening due to causes other than particle size, B_0. The broadening due to particle size is then given by the relation,[2]

$$B = \sqrt{B_m^2 - B_0^2}$$

Since the two patterns corresponding to 4(*a*) and 4(*b*) were taken under identical conditions, the half-intensity breadth of the cristobalite peak is a safe upper limit for B_0. It is evident that B_0^2 is negligible compared with B_m^2. Using the Bragg particle-size equation,[3] the average crystalline particle dimension, L, may be calculated as follows:

$$L = \frac{0.89\Lambda}{B\cos\theta} = \frac{0.89 \times 1.54}{0.181 \times 0.98} = 7.7\text{A}.$$

This means that if the crystallite hypothesis is assumed, the average dimension of the cristobalite crystallites can not be greater than about 8A. It might be pointed out that the various workers who have favored the crystallite theory have published considerably larger values. Valenkov and Poray-Koshitz[4] give 10 to 12A, this value being obtained, however, from patterns taken with much less favorable experimental conditions.

High cristobalite is cubic and low cristobalite, pseudocubic, the cube edge of the unit cell of both being 7.0 to 7.1A. The particle-size determination then demands that, on the basis of the crystallite theory, we postulate that the major part of the material is in the form of cristobalite crystals scarcely larger than one unit cell. Since the term, "crystal," means a form of matter in which some unit of structure repeats itself identically at regular intervals in three dimensions, it is stretching the term so far that it loses all meaning to apply it to volumes of the order of one unit cell. It is pointless, furthermore, to argue that the true crystals are larger than 8A but that the outer parts are sufficiently distorted to give the lower experimental value. What one calculates from the particle-size equation is the size of crystal sufficiently undistorted to be called a crystal. It must be concluded from the particle-size study that the use of the term, "crystal," in connection with vitreous

[2] The statement to be found in many textbooks that the two broadenings are linearly subtractive is incorrect.

[3] W. H. Bragg and W. L. Bragg, The Crystalline State, p. 189. Bell & Sons, London, 1933.

[4] N. Valenkov and E. Poray-Koshitz, "X-Ray Investigation of the Glassy State," *Z. Krist.*, **95**, 195 (1936); *Ceram. Abs.*, **15** [6] 193 (1936).

silica is an extension of the term beyond the point where it has any simple meaning or significance.

IV. Small-Angle Scattering Study

For the sake of argument suppose we continue to assume that glassy silica is composed of cristobalite crystallites. The next question of interest is how would these little crystals join on to one another? Are they discrete particles, with definite boundaries, and breaks in the scheme of bonding between two particles, or is the glass a perfectly continuous arrangement of atoms with no breaks or voids? In other words, is glass like a pail full of pebbles or like a pail full of water? This question can be answered definitely by consideration of the small-angle X-ray scattering.

Figure 3(*c*) shows the microphotometer record of the diffraction pattern of a dried commercial silica-gel powder. It was taken under exactly the same conditions as the vitreous silica pattern in 3(*a*) and is therefore directly comparable. As can be seen, the main peaks of the two patterns are practically the same, but the silica gel shows an intense scattering at small angle, while the scattering curve of the glass approaches zero intensity at small angle. Intense small-angle scattering is characteristic of materials made up of small discrete particles with gaps and voids between them.[5] For example, carbon black shows an intense small-angle scattering comparable with that of silica gel. The absence of small-angle scattering is a direct indication of a *continuous* medium. One means of course "continuous" on a scale larger than that of atomic distances.

The complete absence of small-angle scattering in the pattern of glassy silica means that not more than a small part of the material could be in the form of discrete particles 5 to 50A in size and having definite boundaries and breaks. The material must be essentially continuous; that is, an unbroken system of bonding which does not allow any boundaries or voids to produce density fluctuations on a 5 to 50A scale.

From the point of view of the crystallite theory, as we go out from one of the 8A crystallites, there must be a continuous system of bonding in all directions. It can not, however, follow the structure scheme of the cristobalite crystal, for if it did the particle-size calculation would have given a different value. To have the different crystals bonded to one another continuously, requires a relatively thick layer of intervening material, which itself can not be crystalline. Thus the continuity demanded by the absence of small-angle scattering requires that if we postulate cristobalite crystallites 8A in size they would comprise only a small part of the material; the major part would have to be the intervening material which joins the crystallites together continuously.

V. General Remarks

From the X-ray diffraction studies on vitreous silica, three important results are obtained directly: (1) the tetrahedral scheme of coördination given directly by the Fourier analysis, (2) the liquid-like continuity in the structure of vitreous silica given by the absence of small-angle scattering, and (3) the fact that, if one wishes to assume cristobalite crystallites as the essential constituent of glassy silica, the crystallites can not have an average dimension greater than about 8A.

As has been mentioned before, the scheme of coördination in vitreous silica is the same as in cristobalite. A man sitting on a silicon atom and looking about him would see 4 oxygen nearest neighbors and 4 silicon next nearest neighbors either in cristobalite or the glass; only if he looks farther than the next nearest neighbors could he see any difference.

As molten silica, in solidifying, cools through the cristobalite range, there must of course be a strong tendency to crystallize out as cristobalite. The essential point seems to be that glass is a form of matter in which this tendency toward crystallization has not progressed far enough to produce any appreciable amount of material that can be called crystalline, but a form of matter which is nevertheless bonded together in a continuous fashion. The term, "random network," was intended to convey this idea in as simple a terminology as possible.

The objection to the use of the term, "crystallite," as a description of the structure of vitreous silica, is that the term ceases to have any simple meaning when the picture is sufficiently restricted to agree with all of the X-ray results. This does not mean that the X-ray results prove the complete absence of any trace of cristobalite in the

[5] B. E. Warren, "Small-Angle X-Ray Scattering," *Phys. Rev.*, **40**, 885 (1936).

silica glass. In the random network, there will be a certain variation in the angle between two bonds to any oxygen, and there will be a wide variation in the orientation of two neighboring tetrahedral groups about the common Si–O–Si bond which connects them. Within limits such as these, the structure varies from point to point in the glass. Here and there, as part of a continuous variety of structures, the cristobalite structure would be expected to have developed far enough to be called a cristobalite crystal. The X-ray results show, however, that these few crystallites can not be more than a small fraction of the whole.

A very small amount of cristobalite would, however, be of great importance in the devitrification process. Here it would act as the seed for crystallization and would be important in favoring cristobalite as the devitrification product. This is in line with the very interesting experiment of Trostel,[6] who finds that with a very small trace of quartz left in the glassy silica, devitrification at about 1300°C gives mainly quartz as the devitrification product. Trostel's experiment leads to the conclusion that devitrification products are not a safe indication of the structure of the glass, but rather an extremely sensitive indicator of small amounts of crystalline-seed material.

In the paper by Valenkov and Poray-Koshitz,[4] there are a number of statements which need correction. They state that the diffraction pattern of glassy substances should, on the basis of the crystallite theory, present diffraction maxima of higher orders (*i.e.*, maxima at large scattering angles), but, on the random network theory, these maxima should be absent. This statement is wholly incorrect. The elementary theory of X-ray scattering in noncrystalline material predicts a series of maxima and minima such as are observed. Even the X-ray diffraction pattern of a gas, such as CCl_4, shows a number of maxima and minima.

The two authors have also mentioned the sharper diffraction peak of a silica-gel pattern in attempting to establish a continuous transition between glassy silica and cristobalite. In doing so they have overlooked the important point that glass is a continuous medium, whereas silica gel is an assemblage of small discrete particles. In small discrete particles one can have any degree of regularity.

VI. Conclusions

From the X-ray results, the following picture of a silica glass is derived. Each silicon is tetrahedrally surrounded by 4 oxygens at a distance of about 1.62A, and each oxygen is shared between two silicons. The two bonds to an oxygen are nearly diametrically opposite one another but the angle may vary a little. The orientation of two neighboring tetrahedral groups about the common Si–O–Si direction of bonding is quite random. With only these restrictions, it is possible to build up a continuous network and, furthermore, a network in which no unit of structure necessarily repeats itself at regular intervals in three dimensions. The term, "random network," has been suggested to express this picture of the glassy state. In a true glass any crystalline material of large enough particle size to give the term, "crystalline," any meaning will be a very small fraction of the whole.

[6] L. J. Trostel, "Quartz as a Devitrification Product of Vitreous Silica," *Jour. Amer. Ceram. Soc.*, **19** [10] 271–75 (1936).

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A STUDY OF AN ALUMINA-SILICA CHECKER BRICK FROM THE REGENERATOR OF A GLASS TANK*

By C. L. Thompson and E. P. Rexford

Abstract

At the end of a campaign, alumina-silica checker brick in glass-tank regenerators occasionally are found to have undergone partial destruction as a result of the separation of an altered surface layer of the brick from the less affected core. In an investigation of such an occurrence, it was found that the outer layer had largely been converted to nephelite by reaction of soda vapors and dust from the glass batch with mullite and corundum in the brick. Thermal expansion determinations showed that the rate of reversible thermal expansion in the altered layer was almost twice as great as that of the unaltered brick. It is concluded that the separation or slabbing of the altered layer was due in part to this difference in thermal expansion and in part to a permanent expansion of the slabbed layer which occurred apparently when portions of the brick substance were converted to nephelite.

I. Introduction

(1) General Considerations

The glass industry was one of the first to investigate thoroughly the advantages of using high alumina refractories. As was true in the cement industry, it soon became evident that the chemical nature of these refractories was such as to give them natural advantages over fireclay refractories. The realization that the glass industry offered a large market supplied the impetus which has led to the development of particular manufacturing methods suited primarily to high alumina refractories. The result has been a marked improvement over early refractories of this class. High alumina compositions are now used extensively in the glass tank, not only in flux and bottom blocks, but also in brick used in certain parts of the furnace above the metal line and in the regenerator chambers.

Within recent years glass tanks, in general, have been operated at higher temperatures to increase the rate of production. This has resulted in more severe conditions for the refractories in the regenerators as well as for the flux blocks and for the refractories in the walls, cap, and ports. In many cases the ports, or the checkerwork, require renewing or repairing before the new flux blocks are needed. In a great many cases, the operating campaign has been increased by the use of high alumina brick of 50 and 60% alumina content in the top five or six courses of the checkers. It is also evident now that the recently developed super-duty fireclay brick may be used advantageously in the checker courses exposed to the most severe action. Their alumina content is only about 43%, but they are exceedingly dense and are otherwise well suited for use as checker brick.

Checkers in the regenerator of a glass tank are subjected to corrosion by vapors and dusts arising from the glass batch. The seriousness of the problem depends upon the furnace construction, the type of glass melted, and the degree to which the furnace is being forced. Thus, in a furnace forced to maximum capacity, the amount of dust carried to the checkers is much greater than in one operated at a lower rate. It has also been shown that the alkalinity of the dust may be greater from a furnace which is being forced.[1] Another result of major importance is the increase in temperature within the checker chamber when the furnace output is increased. The temperature governs the nature and severity of the reaction between the brick and alkali dust and vapor. If the temperature at the checker is moderately low, the furnace dusts may accumulate as a crust which tends to close the flues. There are provisions, however, for removing such dust formations without shutting down the furnace. Higher temperatures cause the dust and alkali vapor to react with the brick, forming a fluid slag exceedingly corrosive to the brick.

High alumina brick undergo less corrosion by alkali vapor and dust than do fireclay brick. This property is demonstrated by the results of

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 24, 1937 (Refractories Division). Received November 15, 1937.

[1] M. C. Booze and F. C. Flint, "Checker Brick for Resisting Alkaline Slags," *Jour. Amer. Ceram. Soc.*, 7 [8] 594–98 (1924).

a test illustrated in Fig. 1. Standard nine-inch straight brick of 40% alumina (high heat duty fireclay brick), 50% alumina, and 60% alumina were set on edge side by side on the floor of a regenerator port of a continuous flat glass tank. The temperature was approximately 2400°F. After about six months the brick were removed for inspection. This test gives some measure of the ability of various refractories to resist the attack of the alkaline dust and vapors. The gases leaving the tank at a relatively high velocity, and laden with dust and vapor, impinged directly upon the exposed surfaces of the test brick. They were consequently exposed to the same influences practically as the checkerwork but in a more severe form. After the test, the brick were set on end (as shown) for photographing. The brick at the extreme left, an untested nine-inch straight, is included in the photograph for comparison with the brick tested. Two effects were noted, *viz.:* (1) apparently a more fluid slag was formed on the fireclay brick than on the high alumina brick, and (2) the amount of erosion was far less for the two types of high alumina brick than for the fireclay brick.

FIG. 1.—Appearance of 40, 50, and 60% alumina brick (9-inch straights) after about six months' exposure on the floor of a regenerator port of a continuous flat glass tank; the untested 9-inch straight (*extreme left*) was included for comparison.

Insley[2] has reported petrographic studies of 60% alumina checkers from two bottle glass tanks. In both cases the surface deposit on the brick was found to be largely nephelite, $Na_2O \cdot Al_2O_3 \cdot 2SiO_2$. In one case the high temperature form of the same mineral (carnegieite) was also present. He reports that these minerals do not form in the hottest parts of a glass tank. His explanation attaches considerable importance to the nature of the liquid silicate or reaction product formed by action of the alkalis on the refractory. If the temperature is low enough (*e.g.*, 1200°C, 2192°F), this liquid will be viscous and will remain on the surface of the refractory where it will have an opportunity to combine with sufficient alkali to form nephelite (or carnegieite) which has a high melting point (about 1525°C) and may therefore build up on the brick. At considerably higher temperatures the liquid reaction product, formed on alumina-silica refractories, may be so fluid that it will flow away from the surface before sufficient alkali has been received to form the refractory mineral nephelite.

[2] Herbert Insley, "Some Observations of Surface Deposits Formed in Glass Furnace Regenerators," *Jour. Amer. Ceram. Soc.*, 9 [10] 635–38 (1926).

(2) Notes on Samples

Material for the present paper was obtained through study of a high alumina checker brick which had been in service during an entire campaign in a regenerator of a tank making plate glass. The duration of the run was 401 days. The brick was one of those in the first bank of checkers where the temperature was the highest. The particular point of interest was that slabs

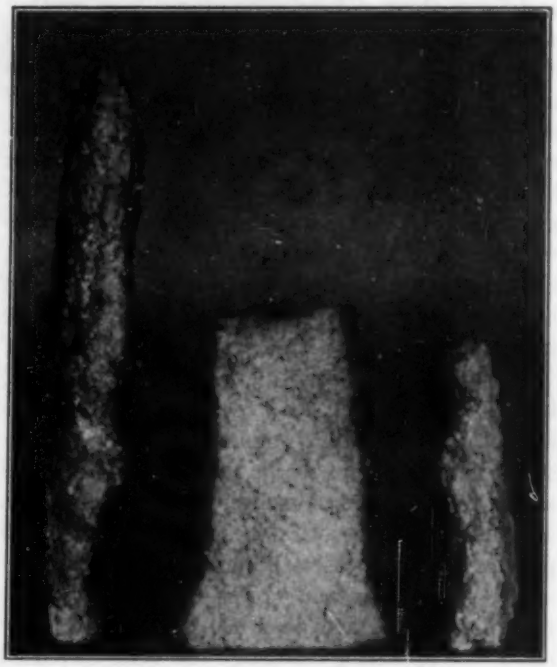

FIG. 2.—Two slabs from a checker brick and a portion of the remaining brick core.

more than one-half inch thick were found to have separated from the faces of the brick. In most cases a thin layer, similar to the slab, had formed on the newly exposed surface of the brick. Two of these slabs and a portion of the remaining brick core are shown in Fig. 2.

This particular type of destruction in glass tank checker brick is not unique, but it is, however, considerably less common than direct slagging action. It has been observed with high heat duty fireclay brick, as well as with high alumina brick. It has occurred with high alumina brick of the 50 and 60% alumina types. The specimen obtained for study was a 60% alumina brick. It was reported that slabbing of 60% alumina brick had been observed in this particular furnace with diaspore-base refractories (as represented by the sample in this study) and with those of the sillimanite type. This would indicate that the nature of the raw materials had less bearing on the phenomenon than the analysis of the refractory and the phase equilibrium relationships.

II. Outline of Tests

Microscopic examination was made of samples from (*a*) the center portion of the checker brick, (*b*) the slabs that had split off, and (*c*) an unused brick of the same brand. The reversible thermal expansion of these three samples was measured by the interferometer method. Chemical analysis, porosity, and specific-gravity determinations were also made on the center and slabbed sections of the used brick.

TABLE I

	Typical data for brand	Center of tile	Slabbed section
Porosity	22–24%	22.5%	15.7%
Specific gravity			
Bulk	2.24	2.25	2.35
Apparent		2.90	2.80
True		2.95	2.81
Chemical analysis			
	(%)	(%)	(%)
SiO_2	33.2	34.7	30.0
$Al_2O_3 + TiO_2$	63.2	59.4	49.8
Fe_2O_3	1.8	1.8	1.5
CaO	0.2	0.4	1.2
MgO	0.4	0.5	0.2
Na_2O	1.2	1.6	11.4
K_2O		1.5	1.6
Ignition loss			.0.9
Unidentified			3.5*
	100.0	99.9	100.1

* Volatilized from HF and H_2SO_4 evaporation and ignition.

III. Results

The thermal expansion curves are shown in Fig. 3 and the other data in Table I.

The unspalled portion of the brick was not found to be significantly different from an unused sample of the same brand in thermal expansion, specific gravity, or porosity. The chemical analysis indicated that a little alkali absorption had occurred. The microscopic examination did not indicate any difference between the center core and the unused brick, nor was there microscopic evidence of the alkali which had been absorbed by the core. Both samples contained considerable corundum that had been derived from diaspore. There was some mullite present in crystals sufficiently large for microscopic identification. From the results of various researches,[3] it can be inferred that it was also present in appreciable amounts in those portions of the brick where immaturity of crystallization makes it impossible to determine the mineral composition microscopically. Photomicrographs of the core and of an unused brick are shown in Figs. 4 and 5.

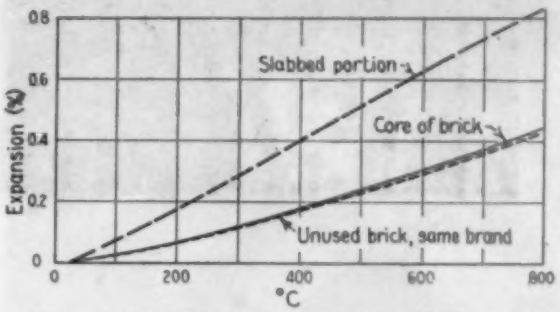

FIG. 3.—Reversible thermal expansion of the core and slabbed portions of a used high alumina checker brick and of an unused brick.

The slabbed portion of the brick had been greatly altered. The thermal expansion of this altered portion was found to be almost double that of the remainder of the brick (Fig. 3). The chemical analysis indicated absorption of a large amount of soda and a smaller amount of lime. Microscopically, this section was found to be composed predominately of nephelite

[3] F. A. Harvey and R. E. Birch, "Mullite Development in Super-Duty Fireclay Brick," *Jour. Amer. Ceram. Soc.*, **19** [11] 322–27(1936).

($Na_2O \cdot Al_2O_3 \cdot 2SiO_2$), with numerous small corundum crystals and occasional patches of mullite scattered through the ground mass (Fig. 6).

IV. Discussion of Results

The results show that the original constituents of the brick had been altered, to a depth ranging up to about one inch, by soda from the glass

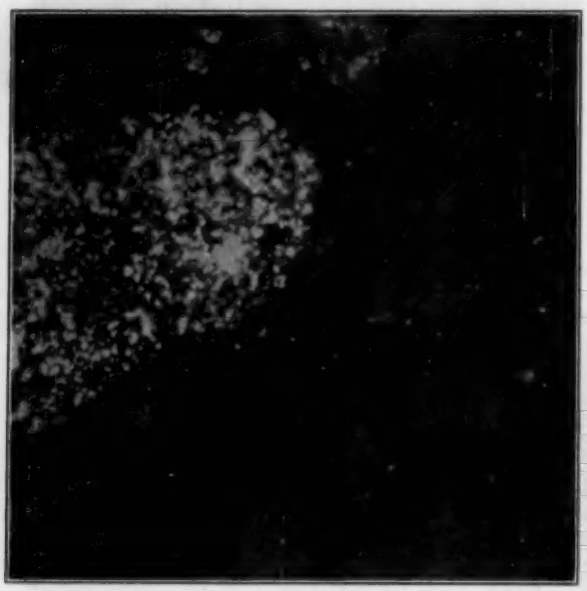

FIG. 4.—Core of used checker brick; crossed nicols; magnification 110×. This section shows a relatively large grain converted mainly to small crystals of secondary corundum; the small white spots are corundum. The dark gray grains of the section are products derived chiefly from diasporitic fire clay; the black portions are pore spaces in the brick.

batch that was carried into the checker chambers by the gases from the glass tank. The reactions which may occur are as follows:

(1) $3Al_2O_3 \cdot 2SiO_2 + Na_2O \longrightarrow Na_2O \cdot Al_2O_3 \cdot 2SiO_2 + Al_2O_3$

(2) $Al_2O_3 + 2SiO_2$ (from the brick) $+ Na_2O \longrightarrow Na_2O \cdot Al_2O_3 \cdot 2SiO_2$

(3) $Al_2O_3 + 2SiO_2$ (from the glass batch) $+ Na_2O \longrightarrow Na_2O \cdot Al_2O_3 \cdot 2SiO_2$

These reactions would be expected to result in a permanent volume expansion, inasmuch as nephelite has a lower true specific gravity than the weighted sums of the original corundum, silica, and mullite. The calculated true volume expansion was about 25%. Further calculations, in which proper allowance was made for the absorbed soda and for the reduction in effective expansion due to the filling of pores, indicated that the bulk volume increase was about 14%.

NOTE: The method of calculation, using the data of Table I, is as follows: Originally 1 cc. (external volume) of brick weighed 2.25 grams; after service the slabbed section weighed 2.35 g./cm.³. Consequently, 1 cu. cm. of original material would have become 2.25/2.35 cm.³, if no components had been added. To determine the degree of alteration, it is necessary to assume that no alumina plus titania was added or taken away. Then the original brick substance comprised the following portion of the altered slab:

$$\frac{49.8}{59.4} = 0.838.$$

Applying this correction for composition change, 1 cu. cm. of original brick substance is found to have yielded the following volume of altered slab:

$$\frac{2.25 \text{ cm.}^3}{2.35 \times 0.838} = 1.14 \text{ cm.}^3$$

Therefore, the calculated exterior or over-all expansion from original brick to altered slab was 14%.

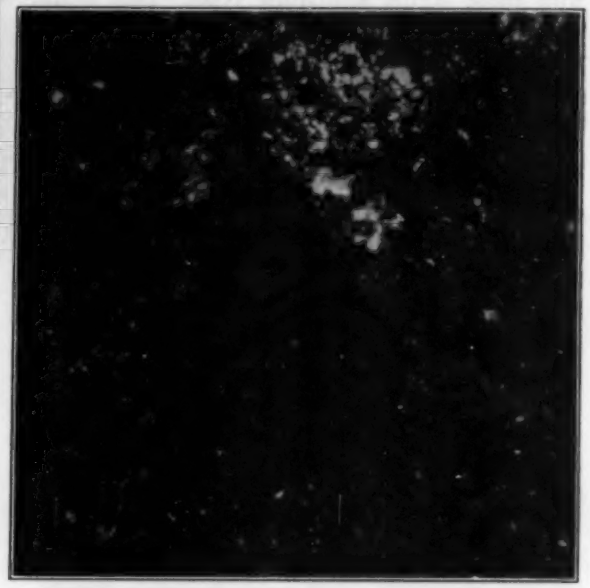

FIG. 5.—Unused checker brick; crossed nicols; magnification 110×. This section shows a portion of an unused 60% alumina checker brick. The white mottled grain in the upper center is a mass of corundum crystals; some of the large gray areas show mullite development in tiny needles; the tiny white specks in the more distinct dark-gray portions represent corundum; the black areas are pores in the brick.

One cubic centimeter, true volume, of original brick became changed as follows:

$$\frac{2.95}{2.81 \times 0.838} = 1.25.$$

The increase in true volume therefore was 25%.

This represents the probable amount by which the slab was expanded, owing to the considerable

conversion of the original brick substance to nephelite and other alteration products.

Calculations of the probable mineral composition of the slabbed section, based on its chemical

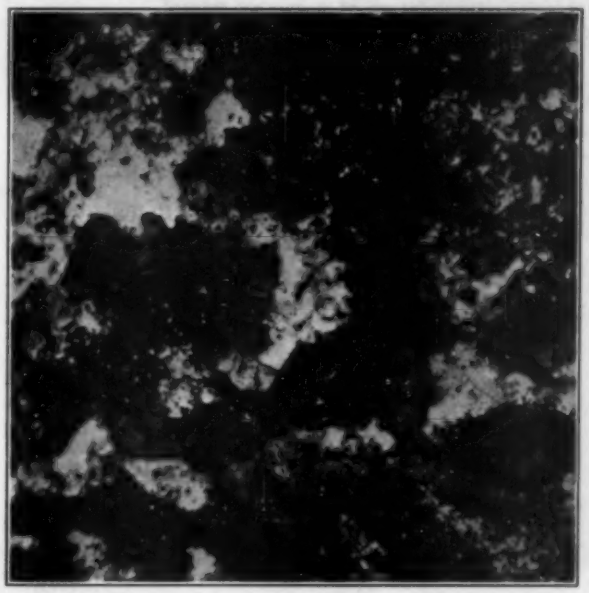

FIG. 6.—Slabbed section of checker brick; crossed nicols; magnification 110×. Nephelite predominates as white to dark gray crystals in various degrees of extinction; corundum shows as small grains in high relief; mullite is also present but not clearly shown in this view.

analysis, indicated that it could consist of 57.7% nephelite, 20.9% mullite, 11.9% corundum, and 9.8% miscellaneous uncalculated constituents.

NOTE: In calculating the mineral composition, nephelite, it was assumed (1) that Al_2O_3 comprised 95% of the $Al_2O_3 + TiO_2$, and (2) that the nephelite contained the potassium and sodium in an isomorphous form $(Na_2K)_2O \cdot Al_2O_3 \cdot 2SiO_2$.

The microscopic examination indicated, however, that more corundum and nephelite and less mullite were present.

Because the reversible thermal expansion of the altered layer was nearly double that of the unaltered part of the brick, temperature fluctuations would cause differential expansion and contraction. Consequently unusual stresses would be set up in the checker brick. Additional stresses would be set up by the substantial conversion of the outer layers to nephelite. This is believed to be indicated by the bowing of the slabs shown in Fig. 2. It is possible, however, that, in the normal regenerator operating range, there was sufficient liquid present to allow partial adjustment of the various stresses and to prevent the complete separation of the slabs from the brick. Assuming the truth of this supposition, the separation of the slabs would occur only when the checkers were cooled below the temperature at which the liquid crystallized or solidified and would be caused mainly by stresses due to the differential thermal expansion.

V. Summary

Soda carried into the regenerator chambers of a glass tank frequently reacts with alumina-silica checker brick to form nephelite as a reaction product. Occasionally the layer of refractory so modified becomes separated as a slab from the less affected core of the brick. In an investigation of such an occurrence, it was found that the separated slab was composed of nephelite with smaller amounts of corundum and mullite and that the rate of reversible thermal expansion of the slab was almost twice that of the less affected portion of the brick. It is believed that the slabbing resulted from this difference in thermal expansion within the brick and from the permanent expansion of the outer section which accompanied the conversion of the brick substance to nephelite and other alteration products.

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EXAMINATION OF AN UNUSUAL CAST IRON*

By G. H. Spencer-Strong

Abstract

Results of chemical analysis and metallographic investigation of a casting which enameled well, but which contained many defects commonly connected with defective enameling, are discussed.

I. Introduction

The examination of cast irons which give rise to defects in enameling is a rather common occurrence in most commercial laboratories. More occasionally an iron will be received which enamels well. Recently a raw casting was received with the statement that it was representative of the product of a foundry which produced especially good castings for enameling. The casting, on examination, proved to be so unusual that it is believed a discussion of its characteristics may be of general interest.

II. Description of Casting

The casting in question was an 18- by 24-inch shut end, with a $^1/_2$-inch flange running lengthwise $^1/_2$ inch from one edge. One side had a $1^1/_2$-inch radius tapered curve at the end. Running lengthwise of the casting, at the opposite edge from the flange was a $^3/_4$-inch flare, wherein the metal thickness increased $^1/_4$ to $^3/_8$ inch.

III. Plan of Investigation

(1) Disposal of Casting

Before blasting, drillings were taken over various parts of the casting for chemical analysis, and a section for metallographic analysis taken from the center portion. The casting was then broken into three pieces, blasted, and enameled with three different enamels, one leadless and two lead. Two further metallographic sections were then taken, one at the center and the other at the flared edge, since this was the only part of the casting which showed any indication of defects.

Table I

Results of Metallographic Investigation

Item	Section A (raw) Amount	Section A (raw) Structure	Section B (nonblistering) Amount	Section B (nonblistering) Structure	Section C (blistering) Amount	Section C (blistering) Structure
Graphite	Heavy	Coarse plates	Heavy	Coarse plates	Heavy	Coarse plates
Pearlite	Heavy	Lamellar coarse	Fairly heavy	Lamellar at edge; lamellar sorbito at center	Fairly heavy	Sorbito at edge; lamellar sorbito at center
Ferrite	None		Some at edge		Very little	
Steadite	Moderate	Heavy; coarse	Same as A		Same as A	
Blowholes	Numerous	Large to fine	Numerous		Numerous	
Iron oxide	Much	Massive	Much	In blowholes massive	Much	Massive
MnS–FeS	Much		Much		Much	
MnS	Some		Some		Some	
Slag	Very little		Very little		Very little	

(2) Chemical Analysis

Routine chemical analysis was run, showing total, combined, and graphitic carbon, silicon, phosphorus, manganese, and sulfur.

(3) Metallographic Analysis

Sections were ground on a rather coarse emery wheel to the elimination of saw marks. They were then leveled down on a fine emery wheel, polished with 0, 00, and 000 emery paper, with levigated alumina on a parafine wheel, and finished with MgO paste on a satin-silk covered block.

Specimens were etched in 10% Nital solution for 10 seconds for examination of general structure. Identification of inclusions followed the plan of Campbell and Comstock, as modified by Wohrman, which is the recommended method of the A.S.T.M. and the Amercian Society for

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Metals,[1] with supplementary reference to Bendicks and Lofquist.[2]

Photomicrographs were made at a magnification of 350×, except as indicated.

IV. Results

(1) Chemical Analysis

The chemical analysis was found to be as follows: total carbon 3.47, graphitic carbon 2.89, combined carbon 0.58, silicon 2.52, phosphorus 0.60, manganese 0.36, and sulfur 0.11.

This analysis indicates a sulfur content slightly higher than is usually believed desirable and a manganese content lower than desirable. The combined carbon appears high.

(2) Metallographic Investigation

Metallographic examination of the casting disclosed numerous blowholes, some of very large size, just under the surface of the casting (see Figs. 1, 2, 3, and 4). Most of the blowholes were either entirely or partially filled with iron oxide (Fig. 2). The largest of the blowholes (Fig. 1) was found to be 1.87 millimeters deep. The surface of the enamel covering it showed no indications of its presence. An idea of its size may be gained by comparison with the thickness of the section in the photograph, the section being actually $^3/_4$ inch thick at this point.

There appeared to be more of a tendency for pinholes to form from the open blowholes (Figs. 3 and 4) than from the oxide-filled cavities (Fig. 2), thus par-

FIG. 1.—Unetched section of enameled casting, showing large blowhole in iron; magnification 12×.

FIG. 2.—Unetched section of enameled casting, nonblistering area, showing large blowhole filled with iron oxide; magnification 350×.

[1] American Society for Metals, Metals Handbook, 1936 ed., Cleveland, Ohio.

[2] Carl Bendicks and Helge Lofquist, Nonmetallic Inclusions in Iron and Steel. John Wiley & Sons, Inc., New York, 1931.

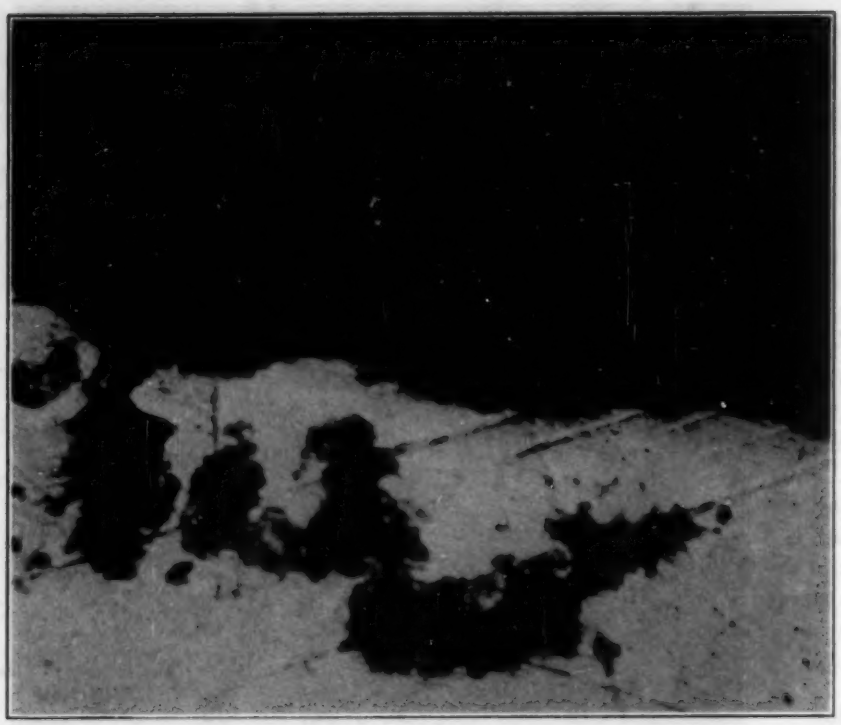

FIG. 3.—Unetched section of enameled casting, showing open blowholes in iron and subsequent blister in the enamel; magnification 150×.

FIG. 4.—Etched section of enameled casting in the nonblistering area showing open blowholes in iron and incipient blister in the enamel; note heavy pearlite after enameling; etched with 10% Nital.

tially refuting the thesis that iron-oxide inclusions in cast iron may cause blistering. In this regard, however, it should be noted that the iron oxide in the blowholes is a different oxide of iron than that found occasionally as small octahedral crystals in cast irons (Figs. 5 and 6).

Graphite in this iron was coarse and rather heavy. There were numerous inclusions, which proved to be MnS, MnS–FeS, and Fe_3O_4 (see Figs. 5 and 6).

Upon etching, the grain structure of the unenameled iron was found to be quite open. Pearlite was heavy and lamellar. Steadite (iron phosphorus eutectic) was fairly heavy. Figure 7 shows the etched, unenameled section. Note the rather heavy well-distributed steadite (white) and the coarseness of the lamellar pearlite.

Examination of the section from the enameled casting showed as many blowholes (in the iron) to be present in the good section as in the bad. Iron oxide was plentiful; in fact, it was found in places between the enamel and the iron (see Fig. 8, to the right and Fig. 4, left center). The blowholes in the good section of the casting appeared to be more nearly filled with iron oxide than in the bad section (compare Fig. 2 with Fig. 3).

Comparison of the sections indicated an incipient blistering condition in the good portion of the casting, wherein the blisters had actually be-

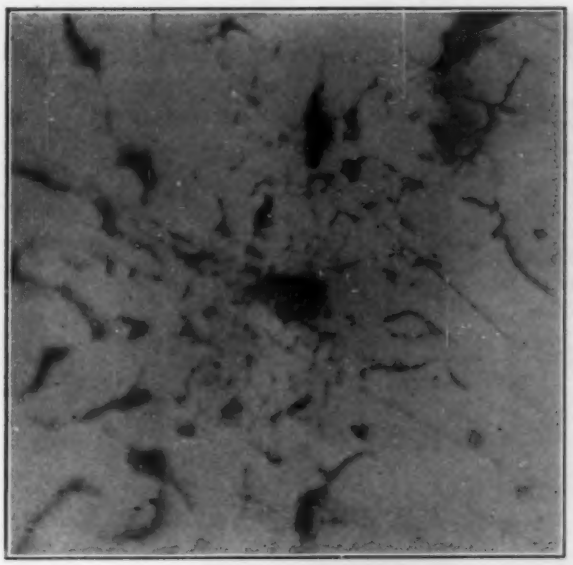

FIG. 5.—Unetched section raw casting, showing graphite formation and inclusions; magnification 300×.

gun to form (Fig. 4) but had not yet left the surface of the iron, whereas in the defective section they had formed earlier and had actually come through the enamel surface (see Fig. 3).

Upon etching, it was found that the combined carbon had only partially broken down during the firing and that there was a rather significant difference in the grain structure of the two sections.

The good section (Fig. 8) showed a very coarse, open structure of lamellar pearlite at the surface, often breaking down into areas of ferrite. Toward the center of the casting, the pearlite became slightly finer. The blistering section (Fig. 9) showed a surface of fine sorbito-pearlite with little or no ferrite, changing into a coarser lamellar-pearlite structure toward the center of the casting.

(3) Enameling

The casting enameled perfectly, with each of the three enamels, except for the fact that there were a few pinholes along the radius of the flare, where the metal section began to increase. The casting would have passed most commercial inspections.

In view of the porosity of the raw casting and the multitude of inclusions therein, the results of the enameling of the casting came more or less as a surprise, since a sound casting was believed to be a prerequisite of satisfactory enameling, and the present specimen was far from a sound casting.

FIG. 6.—Unetched section enameled casting, showing graphite formation and inclusions.

FIG. 7.—Etched section of raw casting, showing coarse and moderately heavy pearlite, steadite, and inclusions; etched with 10% Nital; magnification 350×

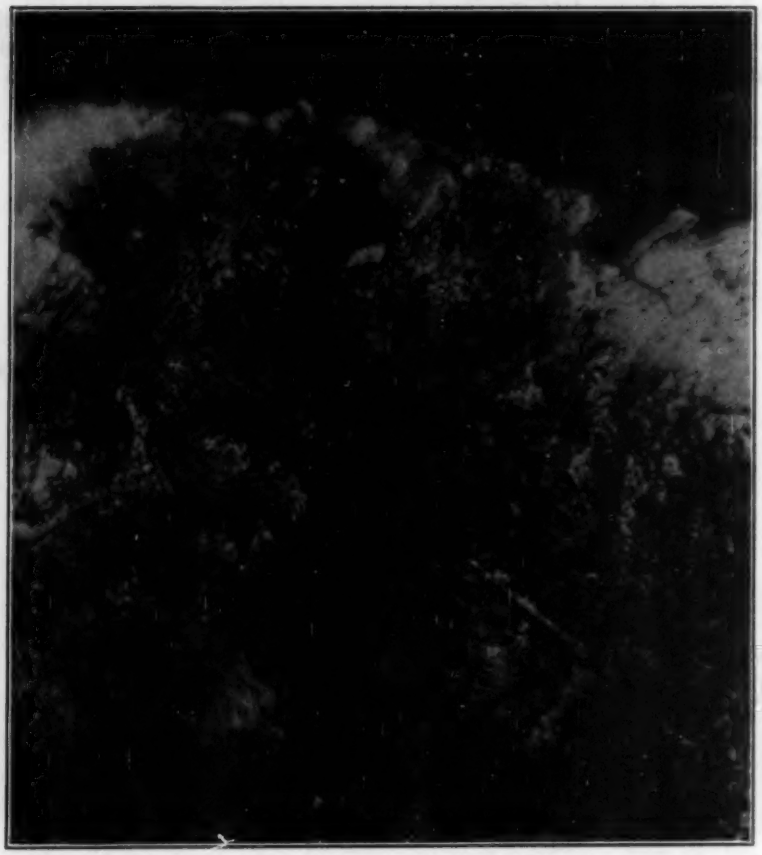

FIG. 8.—Etched section of nonblistering area, enameled casting; magnification 350×; note ferritic areas at surface and increasingly heavy pearlite toward the center of the casting; etched with 10% Nital.

V. Comment

No attempt will be made to formulate any general conclusions from this investigation. There is an indication, however, that some factors, which are generally believed to be deleterious in cast irons for enameling, may be less harmful than usually supposed. It will be noted that the casting showed no burned-in sand condition and there were no chill spots. There is also a strong indication that grain structure may be more important than was believed in the past and that more care should be taken in correlating iron temperature and pouring practice with molding and general design.

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FIG. 9.—Etched section of enameled casting, blistering area; note heavy pearlite at edge of casting; etched with 10% Nital; magnification 350×.

MODIFICATION OF THE BINGHAM PLASTOMETER*

By J. T. Irwin and R. E. Bevis

Abstract

A brief review of the literature on methods of determining consistency of enamel slips is given, followed by a description of a simplified method, making use of two capillaries of different lengths and involving only one time measurement and two volume measurements per determination.

I. Introduction

Since the time when Bingham[1] proposed that clay slips be forced through a capillary of known dimensions under several constant pressures and that the rates of flow be plotted against the pressure causing such flow, to determine the consistency of clay slips, much similar work has been done.[2]

A more rugged apparatus for determining the relative consistencies of various enamel slips was found later in the Gardner mobilometer,[3] which was used in several reported studies[4] of enamel-slip consistency.

Shearer[5] describes an instrument for determining clay and enamel-slip consistencies which has proved practical in many shops.

With any of the instruments mentioned, several time or volume readings, or both, were required to get one set of data for drawing the consistency curve, and, of course, at least duplicate runs were required for reasonable accuracy of results. In many cases, it has been necessary to make several consecutive runs to get a reliable average set of figures.

To simplify the work required to get sufficient data for a relative consistency curve, advantage was taken of the following equation used to calculate shearing stress in dynes per square centimeter when using the Bingham consistometer or the Harrison modification:

$$F = \frac{RhDg}{2l}$$

Where F = shearing stress (dynes per sq. cm.).
R = radius of capillary.
h = average effective height of slip (cm.).
D = specific gravity of slip.
g = gravitation constant 981.
l = length of capillary (cm.).

When using the Bingham consistometer, the factor, h, is varied, all other factors remaining constant to obtain variable shearing stress values. If the above equation holds true, however, either the factor R or l can be varied and identical results obtained.

II. The Irwin Consistometer

Taking advantage of this fact, an instrument was constructed with the average hydrostatic head and radius of capillary constant and with the shearing stress varied by variable length of the capillary.

Instead of the usual one capillary, two capillaries are placed in the end of a long wide-bore tube. Both capillaries are approximately the same inside diameter, but one is about twice as long as the other. When the enamel slip is placed in this large-bore tube and allowed to run from one established level mark to another to give an average hydrostatic head of some standard value, the rate of flow through the shorter

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* Scheduled for the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 27, 1938 (Enamel Division). Received November 17, 1937.

[1] E. C. Bingham, "Bingham Plastometer," *Proc. A.S.T.M.*, [II] (1919–1920).

[2] (*a*) R. D. Cooke, "Plastic Properties of Enamel Slips," *Jour. Amer. Ceram. Soc.*, **7** [9] 651–55 (1924).

(*b*) R. E. Wilson and F. P. Hall, "Measurement of Plasticity of Clay Slips," *ibid.*, **5** [12] 916 (1922).

(*c*) W. N. Harrison, "Controlling Consistency of Enamel Slips," *Bur. Stand. Tech. Paper*, No. 356, 34 pp. (Sept. 30, 1927).

[3] Scientific Section Educational Bureau, *Amer. Paint and Varnish Mfrs. Assn. Circ.*, No. 394, p. 317 (Oct., 1931).

[4] (*a*) G. H. McIntyre and J. T. Irwin, "Application of Gardner Mobilometer to Enamel Slip Studies and Controls," *Jour. Amer. Ceram. Soc.*, **15** [8] 433–38 (1932).

(*b*) W. N. Noble and G. S. Lindsey, "Investigation of Some Physical Factors Affecting the Draining Qualities of Ground-Coat Enamels," *ibid.*, **18** [10] 308–14 (1935).

(*c*) G. H. McIntyre, J. T. Irwin, W. K. Carter, and R. M. King, "Effect of Sodium Aluminate on Consistency and Acid Resistance of Some Acid-Resistant Enamels," *ibid.*, **16** [7] 315–18 (1933).

(*d*) G. H. McIntyre and P. E. Gerdes, "Effect of Neutralizing Solutions on Ground-Coat Draining," *ibid.*, **19** [9] 253–56 (1936).

(*e*) G. H. McIntyre and R. E. Bevis, "Frit Solubility: I, Comparison of Methods of Determination and Relation of Soluble Salts to Enamel Slip Consistency," *ibid.*, pp. 249–52.

(*f*) G. H. McIntyre and R. E. Bevis, "Frit Solubility: II, Controlled Variables of Frit Composition and Their Relation to Enamel Consistency." Paper in type; will be published in an early issue of this *Journal*.

[5] W. L. Shearer, "Control of Ceramic Slip Plasticities," *Jour. Amer. Ceram. Soc.*, **15** [11] 622–29 (1932).

capillary will be greater than that through the longer capillary. By letting the enamel slip from each capillary run into separate graduates and by timing the total time required for the enamel to flow from the one established level mark on the large-bore tube to another, lower, established mark, the rate of flow through each capillary can be calculated. Then in the equation for shearing stress,

$$F = \frac{RhDg}{2l},$$

Rhg becomes a constant value which depends on the average height of the slip and the dimensions of the capillaries. The shearing force for the long capillary can then be expressed as F_1 equals K_1D, and, for the shorter tube, F_2 equals K_2D, where D is the specific gravity of the enamel slip. Plotting these values against the rates of flow through the corresponding capillaries, two points are obtained through which a straight line can be drawn. Each point corresponds to the shearing stress developed in each of the capillaries. The line drawn through these points gives the consistency curve for the enamel slip and indicates both yield value and mobility in the same way as the data obtained from a consistometer tube such as was used by Cooke.[6]

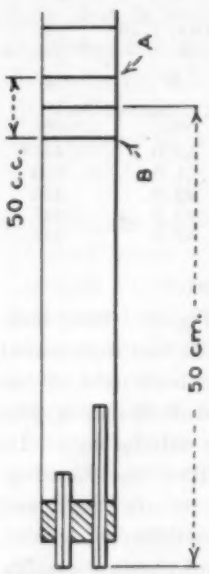

FIG. 1.—Irwin consistometer.

The dimensions of an instrument of this type which has proved of practical value in this laboratory are as follows:

Wide-bore glass tube, inside diameter 3.5 centimeters, length 80 centimeters; established level marks on tube at 55 and 45 centimeters are set from bottom of capillaries when in place. This gives average enamel slip height of 50 centimeters, and permits flow of 50 cubic centimeters of slip in dropping from one level mark, A, to a lower level mark, B.

Capillary No. 1 0.0991 cm. radius
12.15 cm. length
$F_1 = 200D$

Capillary No. 2 0.1005 cm. radius
6.10 cm. length
$F_2 = 403D$

NOTE: Radii of capillaries were determined from weight of mercury required to fill capillaries.

Two 50 cubic centimeter graduates are placed under the capillaries and covered with a watch glass. The large-bore tube is filled with enamel slip of known specific gravity and allowed to run out of the capillaries. When the enamel-slip level reaches the 55-centimeter level mark, the watch glass is removed, and a stop-watch is started. When the slip level reaches the 45-centimeter level mark, the watch glass is again placed under the capillaries, and the stop-watch is stopped.

The graduates are removed, the volumes in each noted, and the rate of flow through each capillary is calculated from the volumes and the time of flow. These values are then plotted against F_1 and F_2. Duplicate or triplicate runs should be made for greater accuracy.

By drawing a straight line through the plotted values, the mobility and yield value of the enamel slip can be determined.

As an instrument for determining consistency in absolute values, this can be criticized on several points. Hall[7] and other investigators have shown that the above equation does not hold absolutely true and that different values are obtained when using single-tube consistometers with capillaries of different bore. No mention has been found of any variable results from capillaries of varied length, but it is possible that this variable also exists. It can be criticized further because only two points are used to plot the curve, whereas other investigations have recommended four to six points. When the aims in the development of the instrument are considered, however, these criticisms are meaningless.

Even if absolute values are not obtained with this instrument, relative values are established.

It is not necessary that absolute units be used. Some value involving length of capillary only may be used, but if values obtained from instruments of similar dimensions are to be compared, it is more convenient to use absolute units.

One argument in favor of this instrument is that with it average results of the curves that

[6] R. D. Cooke, "Controlling Consistency of Enamel Slips," *Jour. Amer. Ceram. Soc.*, **7** [9] 651–55 (1924).

[7] F. P. Hall, "Plasticity of Clays," *Jour. Amer. Ceram. Soc.*, **5** [6] 346 (1922).

would be produced by each of the two capillaries, if they had been used individually as single-tube consistometers of the Harrison type, are obtained. As a matter of fact, when each of the capillaries mentioned above were used as single-tube consistometers, the resulting consistency curves for ground coats and cover coats of commercial consistency checked each other closely. A slight variation in slope and yield value were noted.

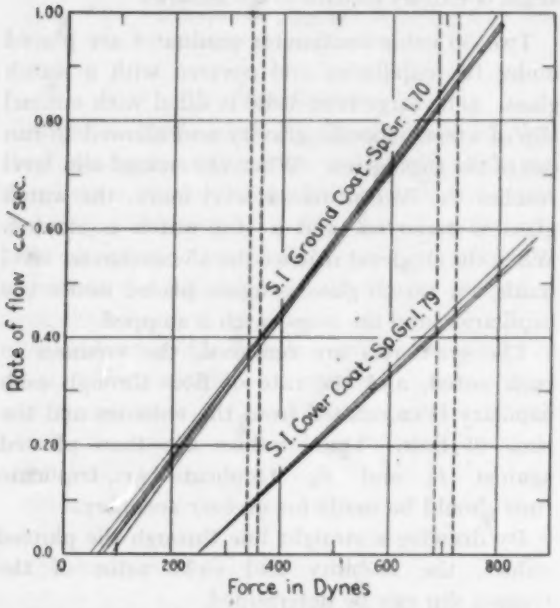

FIG. 2.—Consistency graphs obtained with an Irwin consistometer. Each line represents a single determination; five individual determinations were made and plotted on each enamel slip. The average of any two determinations would result in a line practically identical (within limits of errors of manipulation) with an average line for five determinations.

Using the two capillaries together, as described, two points were obtained which, in each case, gave a consistency curve that was a good average of the two curves obtained when the tubes were used singly.

In order to check the reproducibility of results obtainable with this instrument, five determinations were made on ground-coat and cover-coat enamels, using a fresh sample of enamel for each determination.

The following results were obtained:

Ground coat, specific gravity, 1.70
F_1 = 340 dynes per sq. cm.
F_2 = 685 " " " "

Time (sec.)	Capillary No. 1 (vol.)	Capillary No. 1 (cc./sec.)	Capillary No. 2 (vol.)	Capillary No. 2 (cc./sec.)
43.0	16.0	0.372	35.0	0.815
44.0	15.5	.352	36.0	.819
43.2	15.5	.359	36.5	.845
43.8	15.5	.354	35.5	.810
43.6	15.0	.344	36.5	.837
Average		.356		.825

Cover coat, specific gravity, 1.79
F_1 = 358 dynes per sq. cm.
F_2 = 719 " " " "

Time (sec.)	Capillary No. 1 (vol.)	Capillary No. 1 (cc./sec.)	Capillary No. 2 (vol.)	Capillary No. 2 (cc./sec.)
94.0	9.5	0.101	42.0	0.447
94.4	9.5	.101	41.0	.435
96.6	9.5	.098	42.0	.455
94.0	9.5	.101	42.0	.447
95.2	9.5	.099	42.5	.447

III. Conclusions

These results are plotted on Fig. 2. They indicate that the limits of error with this instrument are small. This instrument has been used by the authors and others in other laboratories for several months and has proved quite satisfactory. Its principal advantages over either the Gardner mobilometer or the consistometer are speed and simplicity of operation, reproducibility of results, and simplicity of calculating and plotting results. It is subject to the same errors as any consistency tube, *i.e.*, plugging of the capillaries with lumps or coarse particles of enamel. The determinations are easily and quickly run. Check determinations of the same enamel can be made in five minutes. The results are easily calculated.

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SOME SPECIAL WEAR-RESISTING MATERIALS FOR CLAY MACHINERY PARTS*

By J. O. Everhart

Abstract

A study of wear-resisting materials for clay machinery parts was made at the Ohio State University Engineering Experiment Station. More than 50 alloy irons and steels were subjected to actual plant tests, *e.g.*, mill knives, die liners, muller tires, and grinder parts. The best of these are discussed from the standpoint of economy and service. Recommendations as to the proper kind of material for various types of installations are given.

I. Introduction

The information presented in this paper is a portion of that secured in a general investigation of metal wear in ceramic plants. The large bulk of data secured in the investigation makes it impossible to present it all through this medium. Accordingly, this work is a discussion of some of the better materials and their possible application to specific services.

II. Method of Test

The tests were made over a period of two and one-half years. The machine parts tested were pug-mill knives, repress die liners, muller tires, dry-pan runner plates, and dry-pan screen plates. During the investigation more than fifty cast irons and steels were studied. Careful day-by-day screen analyses, moisture content determinations, and physical checks on the material being processed were made so that no possible variables might affect the results.

For presentation in this paper, the tests on different machine parts will be considered separately. The pug-mill knife phase warrants a more detailed discussion than the other phases since a greater number of materials were tested, and, in a general way, the behavior of a material in this service is a fair prediction of its behavior in other branches of service.

III. Pug-Mill Knives

The property of abrasive resistance is important. The property of strength and resistance to fractures from shock is of increasing importance in view of the present trend toward de-airing in closed mills, a condition under which the operator has no opportunity to observe a failure and stop the mill before damage is done.

The item of original cost is of varying importance, depending on the machine part in which a material is being used.

The installation cost of pug-mill knives is practically nil, whereas it is of major importance in die-liner service where machine-shop costs are the chief item. In brief, cost of material is a larger factor than labor in installing a new set of knives (or muller tires), but the situation is reversed in installing a new die liner. Therefore, a good material for pug-mill knives should combine resistance to abrasion and mechanical strength and should have a reasonable cost per pound.

In Table I, data are presented regarding a few of the total of forty-two knife materials tested. Not all are recommended for use, several being inserted because they represent general classes of irons and steels with which it is desirable to compare the others. In a general way, their behavior as knives is also characteristic of the results secured in other tests.

One of the first facts that became apparent in examining the data from the forty-two members of the series is that, as a group, the cast irons are far superior to the steels or malleable irons in wear resistance. This is shown in the thirteen members listed in Table I.

Material A, a typical white cast iron, was adopted as a standard of comparison for all the materials. Alloy cast irons as a group are represented by materials H to TP12, inclusive, in Table I. Their wear resistance as a group is very much better than the steels or malleable irons and appreciably better than the normal unalloyed white iron, A. The material identified as TP12 was originally developed for use in sand-blasting and showed such promise that it was included in these tests. Its behavior was excellent. Material H, another special alloy, very high in chromium, has also given excellent service. The nickel-chromium cast iron, X, which has been on the

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 24, 1937 (Materials and Equipment Division).

market for some time as metal for special abrasive service, behaved well as did the molybdenum-chromium iron, R20. The material, 63, is reported because it can be easily produced, is inexpensive, and gives considerable improvement over the ordinary white iron.

In the course of the investigation, two steels were tested, (1) as produced and (2) with a simple heat treatment. It was hoped that some simple and inexpensive treatment might improve their behavior enough to warrant its application. Improved wear resistance was secured, but it was scarcely sufficient to justify the effort. Materials Si and Si(N) are examples. They are the same except that Si(N) was heat-treated as shown in Table II.

TABLE I

CHEMICAL COMPOSITION, HARDNESS, AND WEAR RESISTANCE OF SOME PUG-MILL KNIFE MATERIALS

Material*	C	Si	Mn	Cr	Mo	Ni	Brinell hardness	Loss % in original weight per 100,000 brick made
C	1.14	0.71	12.15	0.97	0.65		217	1.64
P	0.35	0.41	1.36		0.17		444	1.62
Si	0.52	1.64	1.13				283	1.98
Si(N)	0.52	1.64	1.13				415	1.69
H	2.53	0.66	0.74	28.14			460	0.38
X	3.40	0.95	0.70	1.50		4.62	700	0.41
63	2.96	1.41	0.50	1.36			461	0.73
R16	3.89	0.99	1.09		1.00		321	0.61
R20	3.13	0.83	1.63	1.06	1.05		477	0.47
TP12	2.00	1.25	0.50	2.95	4.95		650+	0.24
A	2.45	1.00	0.45				321	0.91
J	2.25	1.00	0.45				217	3.65
MH	2.25	1.00	0.45				514	1.63

* C is a representative manganese steel.
P, Si, and Si(N) are representative steels; Si(N) differs from Si only in heat treatment.
H to TP12, inclusive, are alloy cast irons.
A is a typical good grade of white cast iron.
J is a malleable iron.
MH is the same as the malleable iron, J, except that it has been heat-treated to give a white iron wearing tip.

TABLE II

HEAT TREATMENT OF PUG-MILL KNIFE MATERIALS

Material	
C	Two hours at 1850°F, quenched in water
P	" " " 1600°F, " " "
Si	None
Si(N)	Two hours at 1650°F, quenched in water, tempered at 850°F
H	None
X	"
63	"
R16	"
R20	"
TP12	Data not available
A	None
J	"
MH	Material J treated to give a white iron structure

Three manganese steels were tested. The abrasive loss on all was high as compared to the cast irons but about equal to the other steels.

Two malleable irons were tested, the material, J, in Table I being one. The other of the same composition was given a chromed surface. Wear resistance of both was poor as compared to the other materials, although the chromium surface temporarily improved the behavior. Another series of malleable iron knives, MH, was heat treated to give a white iron structure to the wearing end. The wear loss was reduced nearly half, but the behavior was still no better than that of steels and not comparable to that of the cast irons.

The use of an unalloyed white iron as cast could not be recommended because of the generally low resistance to shock. The alloy irons all have considerable strength and, in general, are strong enough to give satisfactory service.

In the exceptional case where stress must be placed on sheer toughness and ability to bend without fracture, the use of steels or malleable irons would be advisable. In the more general case, the use of alloy cast irons is recommended.

Materials of the type of A and the alloys R16, R20, and 63 are easily available and their cost is reasonable. The minor amounts of alloy materials in irons of the type of R16, R20, and 63 increases the price only about one cent per pound. In addition to the improved resistance to wear, the uniformity of product and percentage of good castings is increased.

The firms producing nickel, chromium, and

molybdenum for alloy purposes are quite willing to give technical assistance to local foundries attempting to produce the alloy for the first time, so no trouble should be encountered in establishing a source of supply.

Materials such as TP12 and H naturally are more expensive than iron, such as A or the steels. From the standpoint of cost, TP12 and H would average from three to five times as much as standard white iron. Both are electric furnace irons and require some special technique in making. They are available, however, from companies already manufacturing them for other purposes and would not have to be secured from a local source. The author's impression is that their field of use is more or less confined to die liners, etc., unless one has a very severe abrasive problem in tempering. Material X, while containing a rather high nickel content, is sufficiently high in carbon to make foundry practice easier and can be made in a cupola successfully. It is being made at the present time at a price not far in excess of the cost of ordinary iron. It warrants careful consideration in selection of materials for this purpose.

TABLE III

WEARING BEHAVIOR OF DRY-PAN SCREEN PLATES

Material	Clay ground (lb.)	Loss in weight (%)
"Mallix" iron	15,185,200	8.16
Malleable iron	15,185,200	11.20
Steel	15,185,200	18.00
Gray cast iron	Broken in test	

IV. Dry-Pan Screen Plates

Four materials were tested for dry-pan screen plates. They were a gray cast iron, a steel, a malleable iron, and a special heat-treated malleable iron. Data regarding their behavior are given in Table III.

From these data, it appears that both the plain malleable and the heat-treated malleable irons are definitely superior to the steel as to wear resistance. The gray iron was found to be too brittle for this type service.

Aside from the question of resistance to wear, another factor, that of screening efficiency, should be mentioned. It is possible to obtain a considerable increase in screen-opening surface by the use of malleable iron. The average malleable plate will have approximately 40% greater opening area than a perforated plate with the same width openings, thus increasing the rate of screening and reducing the circulating load in the pan. Another factor not to be disregarded is that, for fine grinding, malleable plates can be made with smaller screening slots than can possibly be secured in a steel plate.

Considering all the factors involved, the malleable iron materials are much the most desirable for screen plates.

TABLE IV

COMPOSITION AND WEAR-LOSS DATA OF MULLER TIRE MATERIALS

Material	Composition						Brinell hardness	Material ground during test (tons)	Weight lost during test (%)	Maximum amount of cupping (in.)
	C	Si	Mn	Cr	Ni	Mo				
X	3.45	0.82	0.90	1.66	4.25			27,973	3.84	0.13
O	0.95			0.25		0.30		27,973	11.66	0.25
C	0.71	0.32	0.87	0.91			283	27,973	12.16	0.31
H	2.62	0.33	0.61	26.73			477	27,973	6.89	0.19

HEAT-TREATMENT DATA

Material	
X	None
O	Data not made available
C	Annealed 1750°F, normalized 1550°F, tempered 550°F
H	None

V. Muller Tires

Four materials were tested for muller tire service. Their composition and wearing behavior are given in Table IV. Materials H and X are essentially the same as the knife materials of the same designation. Materials O and C are steels now being used for tires in the industry.

From the data in Table IV, the material, X, seems to be the best of the four tested because it had considerably less wear and costs only a little more than the steels. Material H, while having good wearing qualities, would be too expensive for this type work. Using the data from this investigation, a foundry in Portsmouth, Ohio, has made muller tires of the high carbon,

nickel-chromium iron, similar to X. They have given from three to four times the service of the white iron and steel used previously.

VI. Die Liners

The die-liner phase of the investigation is not completed, but twelve of the seventeen materials to be studied have been tested.

These materials have been tested in a two-mold firebrick repress, by lining one mold box with the test material and the other with a standard white iron. Of the twelve tested to date, only two materials of composition similar to H and X have given better service than the standard white iron. The composition, H, gave approximately ten times, and X three times, the service of the standard iron. Both materials offer some machining difficulty owing to their hardness. The one, H, can be machined, but X must be ground. The average machine shop can handle both.

TABLE V

DIE-LINER MATERIALS

Material	Composition								Brinell hardness	Relative wear loss white iron as 1.000
	C	Si	Mn	Cr	Mo	Ni	Al	Co		
WI	3.50	0.32	0.06						415	1.000
H	2.53	0.66	0.74	28.14					601	0.093
E	0.35	1.36	0.41		0.17				321	3.174
L	0.20		0.60	1.00	0.25	3.50	1.00		444	2.027
X	3.50	1.00	0.70	1.50		4.50			601	0.315
D	1.50	0.60	0.40	13.00	0.80	0.45		3.50	653	1.896
MOX	2.95	0.85	1.47	0.54	1.01				477	1.264
SL	1.79	0.31	0.34	12.55				Va 0.06	653	1.379
NO	2.30	0.60	0.40	12.50		0.50		Va 0.15	555	1.156

VII. Summary

Brinell hardness of a material can not be taken as a measure of its wearing property except in a general way.

For mill knives, muller tires, and die liners, the alloy cast irons are to be recommended over steels, malleable irons, or unalloyed cast irons.

Simple alloy irons with low percentages of chromium and molybdenum, such as compositions 63 and R20, are appreciably better than the straight irons and cost only a little more. They should be especially good for mill knives. For particularly severe service, the materials X, H, and TP12 can be used. Of these three, X is less expensive than the others and justifies consideration along with the cheaper materials.

For dry-pan screen plates, malleable irons were found to be superior to steel and gray cast iron from the standpoint of wear and screening efficiency.

For die liners, a high chromium cast iron, H, and a nickel-chromium cast iron, X, were far superior to ten other steels and irons tested. These are both recommended for this service.

For muller tires, both the chromium and nickel irons, H and X, gave good results. The material, H, is too expensive to be used for such service, but X should do nicely.

In general, a material that wears well in most services will also do well in the others. The fact that it is the best for one particular installation, however, does not indicate that it will be the best for another.

Ordinary mild steel can be heat-treated to improve the wear resistance, but the improvement is hardly sufficient to justify the cost and trouble.

Acknowledgment

The investigation was a coöperative one between the Engineering Experiment Station at Ohio State University, twelve companies producing iron and steel materials, and he Ironton Fire Brick Company, where the tests were conducted.

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February, 1938
17—2

Abrasives

Effect of different clays on the physical properties of grinding wheels. Edgar Denninger. *Ber. Deut. Keram. Ges.*, **18** [3] 106–109 (1937).—The determination of resistance to tearing of sintered grinding-wheel bonds and grinding-wheel bodies made thereof makes it possible to recognize the influence of different clays on the toughness or tenacity of bonds and bodies. The studies carried out confirmed the fact that increasing the clay substance to a definite limit (about 35%) increases the toughness of the bonds and grinding-wheel bodies. Mixing of clays of different tear resistance does not produce a mix with a medium tear resistance but generally produces a low tear resistance which can not be predetermined. Grinding-wheel bodies of silicon carbide of medium grain (No. 60) with 25% bond addition display approximately as high a tear resistance as that of pure bonds with a fine stoneware nature. E.J.V.

Laws of crushing and grinding: current research and results obtained. E. C. Blanc. *Rev. Ind. Minérale*, No. 386, pp. 35–43 (1937); *Chem. Abs.*, **31**, 2047 (1937).—B. reviews work since the time of Rittinger, 1867, under 3 headings: theoretical study of energy absorbed, character of particles resulting from grinding, and efficiency of grinding in abstract terms. About 50 references.

Limits of accuracy in grinding of plane surfaces. J. Schröck. *Werkstattstechnik*, **31** [8] 177–79 (1937); abstracted in *Physik. Ber.*, **18** [15] 1352 (1937).—S. discusses the effects of the shape of the piece to be ground, manner of clamping or holding, grinding pressure, method of measuring, temperature at grinding, and grinding machine on accuracy. M.H.

Machining flat surfaces by disk grinding. Anon. *Machinery* [London], **47**, 129–33 (Oct. 31, 1935); *Metals & Alloys*, **7** [3] MA133 (1936).—A new, deep-corrugated or plane face, coarse grit, grinding disk is used. The deep corrugated disk, like a circular waffle, always presents a sharp surface. It is mounted horizontally, vertically, or duplex to grind opposite faces simultaneously. Production figures and costs are discussed, and the various types of machines and wheels and products handled are shown. Some of the disks are in one piece; others (the larger ones) are built up with removable sectors.

Optical investigations of magnesium silicate bodies. Max Pulfrich. *Ber. Deut. Keram. Ges.*, **18** [5] 177–93 (1937).—After a thermochemical discussion of the MgO–SiO_2 system and the work of other investigators, P. describes his findings on making petrographic examinations of magnesium silicates produced from different crude sources of magnesium silicate, such as soapstone, talc, and periclase. E.J.V.

Polishing and buffing special metals. R. S. Leather. *Platers' Guide*, **31**, 19–20 (Aug., 1935); *Chem. Abs.*, **29**, 7247 (1935).—Precautions are noted in polishing Cd, Cu, Cu-pewter ware, and other soft metals, Pt, Pb, and Pb-Sb alloys, Britannia metal, and sheet Sn.

Rapid grinding technique for new and damaged carbide tools demonstrated. Carboloy Co., Inc. *Steel*, **98**, 46–47 (June 1, 1936).—A series of educational demonstrations in various cities, showing an improved technique for grinding carbide tools, reveals a drastic reduction in tool grinding time. The important features include (1) proper dressing of grinding wheels for rapid grinding, (2) maintenance of constant motion of the tool while grinding, (3) use of double or composite angles in the tools, and (4) alternate grinding of the carbide tip and steel shank when necessary to hog off large amounts of the stock. Other factors such as proper wheels, correct machines, fixtures, etc., are also involved. H.E.S.

PATENTS

Abrading device. P. J. Huhn. U. S. 2,100,780, Nov. 30, 1937 (Dec. 24, 1934). An abrading device comprises a spindle, a wheel having a slotted opening in the periphery thereof mounted freely rotatable thereon, a strip of abrasive material rolled on the spindle and rotatable therewith, the free end of the strip passing outwardly through the slot and around the periphery of the wheel and then inwardly through the wheel to the spindle, the strip constituting a driving connection between the spindle and wheel, and means interposed between the spindle and the wheel for elastically controlling the relative rotation of the wheel and the spindle during an abrading operation.

Abrading tool. T. F. Quigley (Micromatic Hone Corp.). U. S. 2,102,092, Dec. 14, 1937 (Nov. 3, 1927).

Abrasive saw tooth. Fred Bley (Carborundum Co.). U. S. 20,560, Nov. 30, 1937 (March 5, 1936); reissue of original U. S. 1,985,972, Jan. 1, 1935.

Abrasive wheel. R. R. Raber (Niles-Bement-Pond Co.). U. S. 2,101,193, Dec. 7, 1937 (Nov. 30, 1934).

Abrasive wheel and method of making. Norton Grinding Wheel Co., Ltd. Brit. 474,110, Nov. 10, 1937 (Nov. 8, 1935).

Buffing wheel. S. W. Lippitt. U. S. 2,100,340, Nov. 30, 1937 (Feb. 3, 1937). W. S. Thomas. U. S. 2,099,777, Nov. 23, 1937 (July 20, 1937).

Cam grinding apparatus. C. J. Green (Norton Co.). U. S. 2,101,796, Dec. 7, 1937 (Nov. 27, 1936).

Chaser grinding means. C. S. Mueller. U. S. 2,099,074, Nov. 16, 1937 (Nov. 29, 1935).

Frictional driving mechanism for spindles, particularly spindles of grinding whee's. H. F. Atkins. Brit. 474,289, Nov. 10, 1937 (April 23, 1936).

Grinder and sharpener attachment for meat grinders. A. J. Kirkland. U. S. 2,100,808, Nov. 30, 1937 (Dec. 14, 1936).

Grinding or abrading wheels. Norton Grinding Wheel Co., Ltd. Brit. 474,340, Nov. 10, 1937 (March 21, 1936).

Grinding device. G. J. Batzer (Micromatic Hone Corp.). U. S. 2,102,053, Dec. 14, 1937 (Sept. 15, 1930).

Grinding machine. C. H. Amidon (Norton Co.). U. S. 2,101,787, Dec. 7, 1937 (March 30, 1936). R. A. Cole and C. H. Amidon (Norton Co.). U. S. 2,101,790, Dec. 7, 1937 (Oct. 14, 1936). George Crompton, Jr., and C. J. Green (Norton Co.). U. S. 2,102,517, Dec. 14, 1937 (Jan. 23, 1936). A. L. DeLeeuw (Norton Co.). U. S. 2,099,161, Nov. 16, 1937 (Aug. 30, 1935). Hans Ernst, Charles Herfurth, and L. F. Nenninger (Cincinnati Grinders, Inc.). U. S. 2,101,644, Dec. 7, 1937 (Sept. 10, 1935). F. E. Johnson (Norton Co.). U. S. 2,102,518, Dec. 14, 1937 (Oct. 12, 1936).

Grinding, polishing, etc., machines. C. F. Ern, Jr. Brit. 474,743, Nov. 17, 1937 (April 2, 1935).

Grinding tools. R. Forkhardt. Brit. 475,668, Dec. 8, 1937 (June 11, 1935).

Grinding wheel. K. F. Whitcomb and H. W. Wagner (Norton Co.). U. S. 2,102,343, Dec. 14, 1937 (July 3, 1933). A grinding wheel of uniform basic structure has an arbor hole throughout and an outer zone and a relatively narrow inner annular zone adjacent the arbor hole impregnated throughout the thickness of the wheel with a strengthening material, the outer annular zone being unimpregnated and unchanged.

Grinding wheel positioning mechanism. C. G. Flygare (Norton Co.). U. S. 2,101,794, Dec. 7, 1937 (Aug. 15, 1935).

Grinding wheel truing apparatus. C. G. Flygare and H. A. Silven (Norton Co.). U. S. 2,101,795, Dec. 7, 1937 (Oct. 8, 1935).

Grinding wheel truing device. G. S. Gould and E. D. LaFleur (Fitchburg Grinding Machine Corp.). U. S. 2,100,954, Nov. 30, 1937 (July 13, 1936).

Honing and lapping machine. T. F. Quigley (Micromatic Hone Corp.). U. S. 2,102,093, Dec. 14, 1937 (May 18, 1928).

Machine for grinding gears. E. W. Bullock, C. T. Galloway, L. O. Carlsen, and R. S. Condon (Gleason Works). U. S. 2,099,674, Nov. 23, 1937 (Nov. 6, 1934).

Machine for grinding or sharpening knives, etc. A. J. Stanley. Brit. 475,216, Dec. 1, 1937 (Oct. 7, 1936).

Machine for grinding tools. S. A. Cogsdill (Cogsdill Mfg. Co., Inc.). U. S. 2,099,724, Nov. 23, 1937 (Aug. 5, 1935).

Machine for turning and polishing cylinders of printing machines. F. A. Goyot. Brit. 475,734, Dec. 8, 1937 (April 23, 1935).

Making abrasive teeth for stone saws. G. W. Chormann and H. J. Cowie (Carborundum Co.). U. S. 2,102,305, Dec. 14, 1937 (Sept. 8, 1933; Feb. 1, 1935; renewed Oct. 30, 1937).

Means for keeping the cutting speed constant in turning lathes, etc., when the working diameter changes. W. W. Triggs (P. I. V. Ketten und Getriebe Ges.). Brit. 475,295, Dec. 1, 1937 (Aug. 11, 1936).

Metal reinforcement for abrasive teeth. G. W. Chormann and H. J. Cowie (Carborundum Co.). U. S. 2,102,306, Dec. 14, 1937 (April 24, 1936).

Mounted grinding or abrading wheels. Norton Grinding Wheel Co., Ltd. Brit. 474,339, Nov. 10, 1937 (March 21, 1936).

Pneumatic tools for grinding, polishing, etc. C. Mary. Brit. 475,476, Dec. 1, 1937 (May 20, 1936).

Portable abrading and filing machines. Briggs Mfg. Co. Brit. 475,714, Dec. 8, 1937 (Feb. 10, 1936).

Portable electric cleaning and polishing tools. A. V. Summers. Brit. 475,518, Dec. 1, 1937 (May 21, 1936).

Precision grinding machine. H. H. Asbridge (Churchill Machine Tool Co., Ltd.). U. S. 2,101,383, Dec. 7, 1937 (Oct. 28, 1936).

Profiling and dressing grinding wheels for grinding screw threads. H. Lindner. Brit. 474,322, Nov. 10, 1937 (April 1, 1936).

Profiling of grindstones. Soc. Anon. de Rectification et d'Engrenages Procédés Minerva. Brit. 475,096, Nov. 24, 1937 (May 17, 1935).

Surfacing machines and abrasive drums for use therein. Durex Corp. Brit. 475,043, Nov. 24, 1937 (May 16, 1935).

Valve grinder. H. S. Hill and C. H. Williams. U. S. 2,099,207, Nov. 16, 1937 (Aug. 7, 1936).

Art and Archeology

Accessions of Greek and Roman antiquities. CHRISTINE ALEXANDER. *Bull. Metropolitan Mus. Art*, **32** [7] 175–77 (1937).—A terra cotta bowl, a vase fragment, an inscribed faience polyhedron, and some painted glass have recently been added to the Museum's collection of Greek and Roman art. A.A.A.

American 18th Century presentation goblet. MARSHALL DAVIDSON. *Bull. Metropolitan Mus. Art*, **32** [9] 215–16 (1937).—An outstanding engraved glass goblet (dated 1791) from the works of John Frederick Amelung at the New Bremen Glass Manufactory, Maryland, is another example of the superior craftsmanship which flourished at New Bremen. A.A.A.

Andirons. G. JEANTON. *Nature* [Paris], No. 10, pp. 465–68 (1937).—Before being manufactured in metal, these accessories were made of terra cotta. J. describes particular types of firedogs and gives their symbolistic significance. R.W.D.

Art of the medieval potter. MARGUERITE MAHOOD. *Clay Prod. Jour. Australia*, **4** [12] 21 (1937).—Palissy and the history of jugs are discussed. The first Toby jug is ascribed to Ralph Wood, a Staffordshire modeller of the early years of George III. H.H.S.

Belgian majolica. J. DANIGRAND. *Clarté*, **10** [7] 8–10 (1937). R.W.D.

Bequest of Emma Townsend Gary. ANON. *Bull. Metropolitan Mus. Art*, **32** [7] 166–67 (1937).—Included in the bequest is a group of 231 pieces of Sèvres porcelain with apple green borders, enriched with gildings and floral designs. Most of the pieces bear the double L monogram of the Sèvres factory with dates ranging from 1759 to 1788. Five of the pieces comprise a breakfast set, and the others are part of a dinner service. A.A.A.

British School of Archeology, Athens. P. FRANÇOIS. *Clarté*, **10** [1] 14–17 (1937).—A display of remarkable archeologic specimens discovered in Greece and Crete is discussed. R.W.D.

Color theory. WALTER GARNER. *Chem. & Ind.*, **54** [37] 827–35 (1935); *Chem. Abs.*, **29**, 7715 (1935).—A color theory is developed explaining color-mixing phenomena by (1) the principle of modification by which all colors apparently spectrally repel each other when mixed, *i.e.*, psychologically or physiologically but not physically; (2) the principle of averaging by which color mixtures give the sensation of the average of their modifications according to (1); and (3) the principle of apparent values according to which the eye accepts all colors at their apparent values and does not apprehend the fundamental color responsible for the modified hue seen according to (1) and (2). The theory assumes four primary colors, adding violet to the usually accepted three (red, yellow, and blue), and gives a coherent physical explanation of all types of color blindness based on the insensitiveness or blindness of the eye to one or more primaries.

Decorating by lines. BRUNO MAUDER. *Sprechsaal*, **70** [33] 423–25 (1937).—The decoration of glassware by means of various types of lines and the devices used are briefly discussed. Illustrated. M.V.C.

Decorative design in Sweden and Denmark. ANON. *Studio* [London], **114** [533] 108–12 (1937).—Reproductions are given of Scandinavian design in pottery, glass, and silver. H.H.S.

Destiny's favor or severity. J. HELBIG. *Clarté*, **10** [6] 5–8 (1937).—H. gives a historical review of several ancient Belgian church windows that have escaped destruction. R.W.D.

Early American wineglasses. M. B. D. *Bull. Metropolitan Mus. Art*, **32** [9] 218 (1937).—Two wineglasses of the type in use in America during the latter half of the 18th Century were given to the Museum by Mrs. John Russel Hastings. A.A.A.

Easily fusible glazes without boric acid and lead. B. V. LYUL'EV. *Keram. & Steklo*, **13** [8] 36–39 (1937).—Glazes without boric acid and lead and whose melting temperature is about 900° (cone 09) can be obtained by using eutectic mixtures. To obtain such mixtures, the raw materials must be of well-defined mechanical and chemical composition because of the fact that variations in the chemical composition will prevent their formation, while changes in the mechanical composition will produce incomplete reactions which require higher melting temperatures and lower the luster of the glaze. Siliceous raw materials should be particles of 15 to 25 microns. The glaze compositions studied were in the following range:

from

$$\left.\begin{matrix}0.8588\ Na_2O\\0.0379\ K_2O\\0.0482\ CaO\\0.0558\ MgO\end{matrix}\right\}\left\{\begin{matrix}0.1819\ Al_2O_3\\0.0029\ Fe_2O_3\end{matrix}\right\}2.2484\ SiO_2$$

to

$$\left.\begin{matrix}0.6485\ Na_2O\\0.0961\ K_2O\\0.1180\ CaO\\0.1374\ MgO\end{matrix}\right\}\left\{\begin{matrix}0.4900\ Al_2O_3\\0.0070\ Fe_2O_3\end{matrix}\right\}0.4580\ SiO_2$$

In the majority of cases these compositions yielded good results. Because of a wide variation in the composition of raw materials (diatomite, dolomite, and feldspar), eutectic mixtures are not always obtained. In such cases, the quantity of the basic components in the batch, diatomite and dolomite, should be varied slightly. M.V.C.

English ceramics. C. L. AVERY. *Bull. Metropolitan Mus. Art*, **32** [8] 197–99 (1937).—Recent gifts to the Museum by R. Thornton Wilson include a Lowestoft cup with tapering spout, decorated in underglaze blue in Chinese style, and a pottery figure symbolic of eloquence. It is sometimes called "Saint Paul preaching at Athens" and was one of the large figures made by Enoch Wood of Burslem about 1787. A.A.A.

Imitation of mother-of-pearl. ANON. *Sprechsaal*, **70** [24] 312–13 (1937).—The manufacture of mother-of-pearl, the materials used, and the obtaining of iridescent effects are briefly discussed. See *Ceram. Abs.*, **15** [9] 272 (1936). M.V.C.

"Jomon-Doki," a prehistoric earthenware: III. S. KONDO, C. KAWASHIMA, AND J. TANAHASHI. *Jour. Japan. Ceram. Assn.*, **43**, 641 (1935); *Trans. Ceram. Soc.*, **35**, 17A (1936).—The results of tests on the change in weight on heating and the determination of the H_2O, C, and CO_2 contents are reported.

Lamp chimney. A. T. *Nature* [Paris], No. 9, pp. 404–405 (1937).—Historical documents referring to the Montgolfier were discovered which throw light on the origin of the glass chimney invented for improving the combustion of oil in lamps. R.W.D.

Painted and stained glass from the Sixteenth Century to the present day. H. MORDAUNT ROGERS. *Jour. Brit. Soc. Master Glass Painters*, **6**, 199–211 (1936–37); *Jour. Soc. Glass Tech.*, **21** [86] A301 (1937).—R. briefly surveys colored glass windows in England and on the Continent.

Persian description of the faience technique at Kashan in A.D. 1301. RUDOLF WINDERLICH. *Jour. Chem. Education*, **13**, 361–62 (1936); *Chem. Abs.*, **30**, 6517 (1936).

Rare and ancient glasses. Buckley's collection. GUNN GWENNET. *Clarté*, **10** [1] 5–8 (1937).—G. describes the collection of ancient glasses offered to the Victoria and Albert Museum, South Kensington, by Mrs. Wilfred Buckley. Most of the specimens are signed by Dutch, German, or English artists. R.W.D.

Syrian glass vase. M. S. DIMAND. *Bull. Metropolitan Mus. Art*, **32** [9] 207–208 (1937).—A Syrian vase belonging to the pre-Islamic period has just been added to the Museum's collection. The vase is globular in shape and of thick brownish glass, the decoration consisting of a horizontal pinched band around the shoulder and, below this, two rows of glass disks. It is assigned to the 6th or 7th Century due to similarity to other examples of known date. A.A.A.

Unfritted leadless glaze. DÜPMANN. *Keram. Rundschau*, **43**, 445–46 (1935); *Brit. Chem. Abs.–B*, **56**, 547 (June, 1937).—A Ca borate-kaolin-SiO_2 glaze fired on a body of clay 55%, quartz 40%, and feldspar 5% in a muffle at cone 2*a* gives a satisfactory product of high luster free from hair cracks.

Worcester china. ANON. *China, Glass & Lamps*, **57** [3] 8 (1937).—In 1751 John Wall, with several others, started a china factory in Worcester to imitate the Chinese porcelains. Working with great secrecy, W. perfected a beautiful, soft porcelain. Chinese influence dominated the factory at first. Later the designers used many Dresden, Sèvres, and other Continental effects. About 1770, a distinct English type of design was created borrowed from the furniture designers, Hepplewhite and Adams. The factory was one of the first to use transfer prints and was a pioneer in using calcined bone in making china. Today it makes bone china exclusively. The factory is the oldest English pottery operating continuously on the original site. G.M.P.

BOOKS

Design in the pottery industry. COUNCIL FOR ART AND INDUSTRY. H. M. Stationery Office, London, 1937. 27 pp. Price 9d. To meet foreign competition it is essential to introduce modern methods of manufacture and at the same time maintain a high standard of artistic appeal. The education and training of suitable operatives is the main subject of this survey. H.H.S.

Industrial art in England. NICKOLAUS PEVSNER. Cambridge Univ. Press, London. 24 pp. of illustrations. Price 16s. Reviewed in *Studio* [London], **114** [532] iv (1937).—P. states that 90% of British industrial art is devoid of aesthetic merit and makes practical proposals for improvement. H.H.S.

Roman Glass from Karanis. DONALD B. HARDEN. Univ. of Michigan, Ann Arbor, 1937. Price $4. Reviewed in *Times Lit. Supp.*, No. 1856, p. 622 (Aug. 28, 1937).—The glass finds of the University of Michigan expedition to Egypt, 1924 to 1929, are recounted. H.H.S.

PATENTS

Decalcomania. F. W. HUMPHNER (Mid-States Gummed Paper Co.). U. S. 2,100,140, Nov. 23, 1937 (Jan. 15, 1936).

Designs for:

Beanpot. C. C. SOULE. U. S. 107,161 to 107,163, Nov. 23, 1937 (Oct. 13, 1937).

Bottle. J. H. FUNKEY (Carr-Lowrey Glass Co.). U. S. 107,225, Nov. 30, 1937 (Feb. 21, 1936). U. S. 107,226, Nov. 30, 1937 (Oct. 25, 1937). W. R. KOHL (Carr-Lowrey Glass Co.). U. S. 106,982, Nov. 16, 1937 (Oct. 2, 1937). F. W. LOHSE (T. J. Holmes Co., Inc.). U. S. 107,024, Nov. 16, 1937 (April 13, 1937). A. I. LORENZEN (Owens-Illinois Glass Co.). U. S. 107,433, Dec. 14, 1937 (Oct. 19, 1937).

Bowl. G. T. GILBY (Wallingford Co., Inc.). U. S. 106,971, Nov. 16, 1937 (Sept. 22, 1937).

Combinet. J. G. RIDEOUT (Columbian Enameling & Stamping Co., Inc.). U. S. 107,093 to 107,097, Nov. 23, 1937 (June 30, 1937). U. S. 107,098, Nov. 23, 1937 (July 22, 1937). U. S. 107,099, Nov. 23, 1937 (July 26, 1937).

Dish. J. E. SPENCE (Hazel-Atlas Glass Co.). U. S. 107,460, Dec. 14, 1937 (Nov. 5, 1937).

Drinking fountain. H. R. TROUT (Standard Sanitary Mfg. Co.). U. S. 107,464, Dec. 14, 1937 (June 22, 1937).

Flask. SIDNEY BRANDEIS (Continental Glass Corp.). U. S. 107,371, Dec. 7, 1937 (Nov. 1, 1937).

Glass bottle. J. T. HAMILTON (J. T. & A. Hamilton Co.). U. S. 106,972, Nov. 16, 1937 (Oct. 1, 1937).

Goblet. A. J. CUNNINGHAM. U. S. 107,040, Nov. 16, 1937 (Aug. 1, 1936). U. S. 107,041 and 107,042, Nov. 16, 1937 (June 30, 1937). U. S. 107,067, Nov. 23, 1937 (June 30, 1937). E. W. NEWTON (Imperial Glass Corp.). U. S. 107,030, Nov. 16, 1937 (March 9, 1937).

Jar. W. E. MACKELFRESH, JR. (Owens-Illinois Glass Co.). U. S. 107,082, Nov. 23, 1937 (Sept. 22, 1937). N. F. STEUER (Owens-Illinois Pacific Coast Co.). U. S. 107,104, Nov. 23, 1937 (Sept. 22, 1937).

Plate. VINCENT BROOMHALL (Edwin M. Knowles China Co.). U. S. 107,064, Nov. 23, 1937 (Oct. 4, 1937). ALEXANDER CRANE. U. S. 106,966, Nov. 16, 1937 (Oct. 1, 1937).

Soup cup. KARL BAYREUTHER. U. S. 107,403, Dec. 14, 1937 (Aug. 1, 1936).

Tumbler. M. O. HANSEN (Libbey Glass Co.). U. S. 106,973, Nov. 16, 1937 (April 14, 1937).

Electrolytic process and apparatus for descaling and/or cleaning metals. J. F. HINSLEY. Brit. 475,929, Dec. 8, 1937 (May 23, 1936).

Cements

Cement hardening, an electrostatic phenomenon. L. JESSER. *Zement*, **25** [52] 899–904 (1936).—The anion structures of silicates, aluminates; and aluminosilicates possess an electrostatic field because some cations (Ca, Ba, Sr, K) remain outside these structures. Calcium ions existing in water solutions are influenced by this field. F.E.V.

Classification of mixed cements. RUDOLF BARTA. *Chem. Listy*, **29**, 153–55 (1935); *Chem. Abs.*, **30**, 1199 (1936).—After making a survey of the chemical and physical characteristics of cements prepared throughout the world, B. proposes and presents a table of classifications in which the groups are based upon (1) clinker base as Portland, Roman, aluminaceous, (2) number of accessory ingredients, (3) quality of the mixture, (4) percentage of the constituents, and (5) method of preparation. A simple code gives any position in the table, and since the chemical analysis of a cement places the cement in a fixed position in the table, the cement can be designated by the code number which will convey a picture of the characteristics and position of the cement to anyone acquainted with the table.

Composition of the charge in the smelting of calcium aluminate slags. G. K. MAGARSHAK. *Legkie Metally*, **4** [4] 3–8 (1935); *Chem. Abs.*, **30**, 706 (1936).—In the fusing of $CaCO_3$ with bauxite for the production of Ca aluminate slags, the extraction of Al_2O_3 from the bauxite depends chiefly on the composition of the slag. The maximum extraction (about 80%) is obtained with a molecular ratio of $CaO:Al_2O_3$ of 1.18 to 1.27. The presence of SiO_2 in the slag does not change this ratio.

Importance of colloidal phenomena in the study of cements containing blast-furnace slag as a base. JEAN CIERET DE LANGAVANT. *Rev. Matériaux Construction Trav. Publics*, No. 330, 49–53; No. 331, 86–93; No. 332, 106–11; No. 333, 131–37 (1937).—The properties of colloids are extensively discussed and the colloidal state of granulated blast-furnace slag is pointed out. At 1600° the 3 chief constituents of slag, CaO, Al_2O_3, and SiO_2, are usually found in the free state in the liquid slag; however, with rapid chilling, the characteristic colloidal formation of SiO_2 is observed. In connection with the conceptions of Le Chatelier and Bary, a general theory of the glass state is developed; the latter is applied to slag containing little SiO_2, and comparisons are made with window glass. Because of considerable polymerization of silica molecules and the stability of colloidal combinations, slag poor in silica and in which lime and calcium aluminate are free possesses good hydraulic properties. The plastic properties of slag treated with water are compared with those of other materials, especially sand. The kind of granulation of slag may have a specific influence. L. discusses how far the present theory of the nature of colloids can be used to explain the phenomena of setting and hardening of hydraulic binding agents containing slag. M.V.C.

Influence of calcining temperature of calcium carbonate upon the properties of the quicklime obtained. S. KONDO, T. YAMAUCHI, AND R. SUMIZAWA. *Jour. Japan. Ceram. Assn.*, **43**, 731 (1935); *Jour. Soc. Glass Tech.*, **20** [77] A11 (1936).—Microscopic observation proved no marked difference in the structure of the products obtained from calcined chemically pure $CaCO_3$; the X-ray diffraction patterns were exactly alike for all quicklime produced at temperatures between 1000° and 1600°.

Jointing cements: VII, Stability of jointing materials under compression and tension at 1300°C. F. H. CLEWS, H. M. RICHARDSON, AND A. T. GREEN. *Refrac. Materials Joint Comm., Inst. Gas Engrs., 28th Rept.*, pp. 21–31 (1937).—Data are presented giving the expansion and deformation characteristics of cements containing ganister and crushed silica brick in admixture, bonded with lime or with a mixture of lime and clay. Lime-silica cements containing crushed silica brick in the coarser fraction may be improved in bonding power at high temperature by the addition of a little clay or bentonite, whereas lime-ganister cements are not improved in this respect. Results are also reported for mixed calcined and uncalcined kyanite-clay cements. There is a slight advantage in using uncalcined kyanite in the fine fraction as a means of counterbalancing the firing contraction due to the clay. For Parts V–VI see *Ceram. Abs.*, **16** [5] 152 (1937). R.F.REA

Manufacture of cement in a blast-kiln type furnace. J. LADOUCE. *Arts & Métiers*, **91** [197] 37–43 (1937).—L. reviews cement manufacturing processes and the evolution of the firing kiln. R.W.D.

Oxychloride cements and their application. H. COURTNEY BRYSON. *Sands, Clays & Minerals*, **3** [2] 137–40 (1937).—The discovery of oxychloride cements, *i.e.*, the reaction of magnesium oxide on magnesium chloride to produce cement, is related, and the recent developments are discussed. A number of recipes are given for various purposes, and directions for the correct procedure in each case are added. M.H.

Pozzuolanic cements. R. G. FRANKLIN AND A. E. J. VICKERS. *Jour. Soc. Chem. Ind.* [London], **54**, 231 (1935); *Trans. Ceram. Soc.*, **34**, 64A (1935).—A brief history of the development of pozzuolanic cements is given, starting with the Greek colonists who discovered the useful properties of volcanic dust found near Pozzuoli in Italy. The difference between natural and artificial pozzuolanas is explained. The results of experiments on a clay in the production of an artificial pozzuolana are given.

Reactions of calcium silicates and calcium aluminates with water. R. NACKEN. *Zement*, **25** [10] 145–49; [11] 164–68 (1936).—N. has purposely limited his investigations to $3CaO{\cdot}Al_2O_3$ and $3CaO{\cdot}SiO_2$. In water solution, lime shows crystalloid properties, systems with a silica component have colloidal characteristics, and those containing alumina show both tendencies. Diffusion is essential in colloidal solutions and convection in true solutions (especially when stirred). The hardening and aging of tricalcium silicate finds a ready explanation. Aluminate forms a small quantity of gel but hydrates crystallize quickly. F.E.V.

Slow setting cements. A. VIÉ. *Arts & Métiers*, **91** [200] 100–103 (1937).—The general considerations and properties are given. R.W.D.

Structure of Portland cement clinkers: II. L. MOHR. *Zeiss Nachr.*, **2** [2] 70–80 (1936).—M. deals in some detail with the examinations made. The following compounds

were examined under the microscope: tricalcium silicate ($3CaO \cdot SiO_2$) and dicalcium silicate ($2CaO \cdot SiO_2$); the latter compound is found in three forms, α, β, and γ. Samples of the above compounds were prepared and their structures examined under the microscope. A series of photomicrographs is given. The three principal constituents of Portland cement clinkers, *viz.*, alite, belite, and celite, are discussed. Alite forms colorless, feebly doubly refracting, optically negative crystals with rectilinear boundaries. Belite occurs in granules of various sizes which show a more or less yellow color, due to the presence of iron combinations, and which reveal a fine striation in two directions in transmitted light. The relation between the types of belite and dicalcium silicate is discussed. The optical properties of belite correspond to those of the dicalcium silicate forms, α and β. Experiments have shown that the slow cooling of the very severely heated or ordinarily heated (1200°C) clinker must always lead to the production of a type of dicalcium silicate. L.E.T.

Theory of hydraulic binding agents. NICOLAS ILTCHENKO AND HENRY LAFUMA. *Chimie & Industrie*, **38** [3] 438–40 (1937).—According to the general theory of setting of hydraulic binding agents developed by Le Chatelier, the transformation of an unstable state into a stable one is due to hydration; however, the presence of water also promotes the transformation of an anhydrous unstable system into another anhydrous system which becomes stable. As an example of this, the setting of aragonite is described. M.V.C.

PATENTS

Aluminous cements. E. W. SCRIPTURE, JR. (Master Builders Co.). U. S. 2,099,176, Nov. 16, 1937 (Sept. 28, 1936). The process of making aluminous cement concrete comprises mixing waste sulfite liquor residue with aluminous cement.

Cement. W. E. TYLER, T. B. DOUGLAS, P. R. CHAMBERLAIN, AND R. A. LOVELAND (Dewey Portland Cement Co.). U. S. 2,101,299, Dec. 7, 1937 (Jan. 10, 1935; Sept. 3, 1937).

Enamel

Application possibilities and further investigation of box furnaces with air circulation. O. GENGENBACH. *Elektrowärme*, **7** [11] 243–51 (1937).—The fast and uniform heating obtainable in furnaces with air circulation is described, particularly in the light-metal industry for annealing, heat-treating, and hardening. The electrical losses on some furnaces were determined. M.H.

Architecture uses enamel at the International Exhibition of Paris. ANON. *Emaillerie*, **5** [9] 7–12 (1937).—Several examples of architectural uses are presented to the public. The house of yachting is panelled outside partly with green porcelain enamel. Twenty shops are made of red porcelain enamel, giving by their variety a good example of the resources afforded by enamel. Porcelain enamel was used in inside decoration with success. M.D.

Artistic enamels at the International Exhibition of Paris. ANON. *Emaillerie*, **5** [8] 19–20 (1937).—In the ceramic pavilion at the exhibition are shown translucent enamels by Gaston Bigard, opaque enamels by Serrières, Dumoulin, Gaston Richet, Henry Dransart, Marty, and Lise Eran, some of them in cloisonné. Enamel is applied to jewelry by Ponard and A. P. Colmant. Limoges enamels by Salandie are also shown. M.D.

Automatic spraying of porcelain enamel speeds production, cuts cost. BINKS MFG. CO. *Steel*, **99** [Nov. 16] 78; [Dec. 14] 50–52 (1936).—Illustrated. H.E.S.

Black enamel for cast iron. RICHARD ALDINGER. *Glashütte*, **67** [31] 481–82 (1937).—Lead enamel used without ground enamel for coating cast iron is slightly resistant to acid solutions and water. When using ground enamel, the lead content can be disregarded as the enamel is more resistant due to the presence of the ground coat. When the latter is not used, however, the cleaning of the iron by means of sandblasting, suitable grinding fineness of the enamel, correct thickness of the enamel layer, and special methods of firing are of the greatest importance. In such cases the lead content can be greatly lowered. The following composition, entirely free from Pb, is discussed: 40 $Na_2B_4O_7$, 10 quartz powder, 25 glass powder, 14 $BaCO_3$, 5 $Ba(NO_3)_2$, 2 Na_2SiF_6, 2 CaF_2, 1 CoO, and 1% MnO_2. Five parts of yellow clay and from 4 to 8% black pigments for 100 parts of the granulated enamel are added to the mill. M.V.C.

Bullard-Dunn process for descaling metals. ANON. *Machinery* [London], **46**, 426–27 (July 4, 1935); *Jour. Iron & Steel Inst.* [London], **132** [2] 446 (1935).—In the Bullard-Dunn process, the work is placed in the descaling bath (which contains sulfuric acid as the base) and made the cathode of an electric circuit. Hydrogen is evolved which serves to remove the scale; simultaneously, a protective film of a suitable metal (lead or tin) is deposited on the descaled surface. Work which is oily or greasy is subjected to electrolytic degreasing in an alkaline bath before treatment. The equipment required is similar to that used in electroplating work. The Bullard-Dunn process is stated to be highly effective and applicable to forgings, heat-treated parts, etc.

Characteristics of iron and steel for porcelain enameling. F. R. PORTER AND J. H. NEAD. *Jour. Amer. Ceram. Soc.*, **21** [1] 9–16 (1938).

Checking cast iron for enameling purposes. L. VIELHABER. *Emaillerie*, **5** [7] 17–19 (1937).—It is necessary to check the composition of cast iron, since the composition of enamel is definite, whereas that of cast iron may vary from one fire to another. One or two analyses of cast iron a week will prevent many enameling troubles in the small foundry where this practice is frequently overlooked. M.D.

Cleaning and pickling sheet iron. TROST. *Emaillerie*, **5** [5] 9–11 (1937).—The actual cleaning is made by annealing; temperature must be kept uniform near 1290°F, air being in contact with all parts. When burning off in the presence of acid the temperature may be only 930°F. Pickling with hydrochloric acid is preferred to pickling with sulfuric acid because (1) there is lower gas evolution for the same weight of scale dissolved, (2) a smoother surface is left, and (3) the bath works at room temperature. See *Ceram. Abs.*, **16** [7] 198 (1937) M.D.

Comparative determination of acid-resistance of enameled ware. K. Azarov and N. Kemmer. *Zavodskaya Lab.*, **6**, 623–24 (1937). P.B. & E.S.

Computations in enamel industry. Linsbauer. *Glashütte*, **67** [24] 387–90 (1937).—Formulas are given for calculating manufacturing costs in the enamel industry. M.V.C.

Drying of porcelain enamel. L. Vielhaber. *Emaillerie*, **5** [1] 13–16 (1937).—V. historically surveys drying devices showing the growing importance given to this stage of the enameling process. The best temperature recommended is 70°C (158°F). The moisture content of the air must be kept sufficiently under the saturation point at the working temperature of the drier. An air draft should be maintained accordingly. M.D.

Electricity in the enamel industry. R. Gautheret. *Electricité*, **19**, 379–85 (1935); abstracted in *Chem. Zentr.*, **1936, i**, 610.—A detailed discussion of processes occurring during enameling, the preparation of enamel, and electrical plants required by this industry is given. See *Ceram. Abs.*, **15** [9] 268 (1936). M.V.C.

Enamel building at Great Lakes Exposition. Ferro Enamel Corp. *Steel*, **99**, 49, 66 (July 20, 1936). H.E.S.

Enamel utensils: New South Wales regulation. Anon. *Australian Food*, **7** [4] 19 (1937).—The 1937 revision of the New South Wales Pure Food Act requires enamel vessels for the storage or preparation of food to be free from Sb, Pb, and As; another requirement is that the vessels, when filled as full as is convenient with boiling 0.5% solution of citric acid in water and allowed to stand for 24 hours without being heated or artificially cooled, shall not yield, on ignition of the residue obtained when a definite proportion of the solution is evaporated, an amount of ash exceeding 1 mg./sq.cm. of surface exposed to the action of the acid. On further treatment with a similar fresh amount of the boiling acid solution and standing, evaporating, and igniting as before, the ash yielded shall not exceed 0.5 mg./sq. cm. H.H.S.

Enameling edges of sheet-iron ware. R. Aldinger. *Glashütte*, **67** [39] 605–607 (1937).—The reasons for the breaking up of enamel on edges and other sharply curved surfaces are usually accounted for by (1) defective raw ware, (2) defective treatment, or (3) defective enamel. In the latter case, especially for colored enamel, it is due to too low a coefficient of expansion of the enamel. Theoretical studies show that tensions are especially great and maldistributed in such curved surfaces and that enamels with a high coefficient of expansion should be used for them. Enamels having a calculated coefficient of expansion of at least 310 to 330 $\times 10^{-7}$ should be used for edges. Dark colored enamel is to be preferred on account of its greater strength. Several enamel batches are analyzed. M.V.C.

Enameling large sheets. Ingram-Richardson Mfg. Co. *Steel*, **99**, 46 (July 13, 1936).—A 675-kw. semicontinuous enameling furnace, using 440-volt, 3-phase, 60-cycle alternating current producing temperatures up to 1600°F, is described and illustrated. See *Ceram. Abs.*, **17** [1] 9 (1938). H.E.S.

Factors influencing properties of acid-resisting enamels. G. H. Spencer-Strong. *Jour. Amer. Ceram. Soc.*, **21** [1] 1–8 (1938).

Magnetic separator removes iron from liquid enamels. Ferro Enamel Corp. *Steel*, **99**, 53 (August 17, 1936). H.E.S.

Metallographic characteristics and enameling qualities of certain cast irons. R. B. Schaal. *Jour. Amer. Ceram. Soc.*, **21** [1] 24–26 (1938).

Microscope determines suitability of steel surfaces preparatory to finishing. H. Allen. *Steel*, **99**, 58–60 (Nov. 2, 1936).—Marked increase in the adherence of an enamel to steel used for refrigerator cabinets has been obtained by noting the surface appearance of the steel prior to enameling. Illustrated. H.E.S.

Mixing of molding sands. H. Uhlitzsch. *Giesserei*, **24** [22] 537–43 (1937).—Classification of molding sands according to grain size in 5 groups (>0.3 mm., 0.3 to 0.2 mm., 0.2 to 0.1 mm., 0.1 to 0.06 mm., and <0.06 mm.) and to loam content (meager up to 8%, medium-fat to 8 to 18%, fat over 18%) is explained and the testing methods are described. The practical behavior of several mixtures with regard to gas permeability, temperature rise due to liquid metal, and strength was investigated and is given in curves and tables. M.H.

Opacifiers in wet and powder enamels. H. Melzer. *Glashütte*, **67** [34] 530–32 (1937).—The respective properties of tin oxide and ceric oxide as opacifiers are discussed. See *Ceram. Abs.*, **16** [2] 58 (1937). M.V.C.

Optical specification of vitreous enamels. Deane B. Judd, W. N. Harrison, and B. J. Sweo. *Jour. Amer. Ceram. Soc.*, **21** [1] 16–23 (1938).

Porcelain enamel in architecture. Anon. *Emaillerie*, **5** [6] 11–25; [7] 7–16; [8] 5–7 (1937).—Various methods available for making enameled sheet-iron panels are studied. A description of the clip-strip system is given, with detailed sketches showing how to apply the clip-strip and hold the porcelain enameled panels in the course of inside and outside panelling. Special care must be taken when enameling sheet iron to be held with clip-strip. The panels must be fired flat, their whole surface being well supported on pins; it is advantageous, however, to maintain both ends of the panels with curved racks so that they will have their vertical ends slightly concave. In this way, perfectly tight vertical joints are obtained on the construction. Several examples of installations are given. *Ibid.*, [10] 18–21. A description is given of the Haskelite system for applying enamel to architecture which consists of a thin enameled sheet iron bound to plywood or compressed fiber cemented to a larger galvanized iron sheet so that the panel can be nailed or screwed onto the wall through the part of galvanized iron extending around the panel. The joints are then calked or covered with a batten. This method can be used either for inside or outside panelling. In the latter case, however, a copper flashing is put under the batten. M.D.

Porcelain enamel for 1937. Ferro Enamel Corp. *Steel*, **99**, 25 (Nov. 23, 1936).—Porcelain enamel on steel for U. S. construction work alone now totals more than one million dollars a year. The modern kitchen, with its electric refrigerator, range, dishwashers, and appliances and the bathrooms of the nation account for 15 million dollars annually. H.E.S.

Pressed steel bathtubs. Three decades of development

climaxed by modern enameled sanitaryware. A. H. ALLEN. *Steel*, **99**, 34–38 (Aug. 31, 1936).—Some of the first steel bathtubs made in the U. S. were made by the Seamless Steel Mfg. Co., Detroit, Mich., 1908. The modern steel bathtub is made by first pressing out the two main sections in one 42-in. stroke of the press. The apron is then blanked out and the three pieces set in special fixtures in the flash-welding machine. In the final press operation, edges of the tub and apron are kicked up to facilitate installation, and the apron is folded down over one side to the proper degree. Success of the present steel bathtub is due to (1) marked improvement in the workability and surface finish of the steel sheets; (2) perfection of automatic electric welding for flash welding; and (3) the building of heavier presses and the design of suitable dies for the drawing of bathtub shells in which no serious thinning down of the metal is found and in which no critical stresses are set up at corners and bends. The advantages of the steel tub are as follows: (1) installation costs less; (2) the tub has a smooth finish which could be painted, if desired, without the expense of grinding or firing; and (3) the steel shell supplies ample strength at less weight and almost instantly takes the temperature of the water admitted to it. H.E.S.

Prevention of corrosion by acids. ANON. *Chem. Age* [Met. Sect.], **33**, 9–10 (Aug. 3, 1935); *Jour. Iron & Steel Inst.* [London], **132** [2] 447 (1935).—A study is made of the use and effect of inhibitors during pickling. The part played by hydrogen during the pickling process is briefly referred to, and the behavior of certain inhibitors in alkaline and acid solutions is briefly considered.

Problem of fishscales in sheet-iron enameling. KAMP. *Glashütte*, **67** [40] 623 (1937).—As a result of observations and studies of the appearance and nature of fishscales in sheet-iron enamels, K. finds the chief causes to be as follows: (1) tension differences produced by various coefficients of expansion of sheet iron and enamel; (2) too great a homogenizing of the enamel; and (3) defective calcining and pickling of the raw ware. M.V.C.

Radiant-tube furnace reduces fuel costs in porcelain enamel firing. J. B. NEALEY. *Steel*, **99**, 52, 60 (Dec. 14, 1936); *Ind. Finishing*, **13** [12] 60–63 (1937).—Gas heated radiant- or hot-tube furnaces which have recently come into general use in the metallurgical industry are being used for the firing of porcelain enamel. The furnace consists of a series of metal tubes located on the inside walls and bottom of the furnace but with ends protruding through the back wall to the outside. A gas burner fires into one end of each tube and an eductor at the other end draws the hot products of combustion through. When in operation, these tubes become very hot and radiate the heat to the work in the furnace. These hot tubes can be used long after their theoretical life, for the negative pressure inside prevents the escape of the combustion products to the inside of the furnace, should any holes appear in the tube walls. Successful tubes have been made of a chrome-nickel (35-12) alloy, centrifugally cast. The gas pressure ranges from 3 to 4 ounces while the air pressure in the eductor is 16 ounces. Automatic temperature control is provided in the form of a single potentiometer, thermocouple, and motor for all gas burners. The advantages consist of economical fuel costs and the assurance of a quick comeback after the plant has been closed. Illustrated. See "Batch—," *Ceram. Abs.*, **17** [1] 7, 9 (1938). H.E.S. + J.L.G.

Raw ware manufacture for enameled sheet-iron ware. RICHARD ALDINGER. *Glashütte*, **67** [26] 415–18 (1937).—A. shows that many enamel defects, whether they appear first during firing of the enamel or later during service of the ware, are due to an unsatisfactory synthesis of the raw ware. A series of such defects are analyzed, and ways for preventing their occurrence are discussed. Illustrated. M.V.C.

Refrigerator cabinets sorted en route from factory to warehouse. GENERAL ELECTRIC CO. *Steel*, **99**, 65–68 (Oct. 12, 1936).—The materials-handling system in the warehouse is a series of interconnecting roller conveyers, controlled at strategic points by phototube actuated automatic switches and at certain points by hand-operated switches, serviced at storage areas by an overhead traveling crane, and providing not only transportation through the entire warehouse but an automatic sorting of the various sizes of refrigerators while they are moving through their respective storage points. Illustrated. H.E.S.

Sanitary articles in enameled stamped sheet iron. ANON. *Emaillerie*, **3** [12] 16–17 (1935); abstracted in *Verre & Silicates Ind.*, **7** [6] 69 (1936).—Lightness and other advantages make enameled stamped sheet iron sanitary articles, perfected by an American firm, preferred to enameled cast iron and porcelain objects. M.V.C.

Sodium fluosilicate as opacifier for enamels. R. ALDINGER. *Glashütte*, **67** [44] 675–77 (1937).—As an opacifier, sodium fluosilicate is suitable for any type of enamel. That unsuccessful attempts were made to use it is accounted for by the facts that it dissolved rapidly on heating and that the enamel used was of unsuitable composition. Sodium fluosilicate has the greatest opacifying effect in enamels rich in alkalis and melting at low temperature because most of the silicon fluoride contributes to opacification. In strongly acid enamels and in enamels melting at high temperature, the greatest part of silicon fluoride is lost by burning. Examples are given showing the possibility of replacing cryolite by sodium fluosilicate. M.V.C.

Stainless steel letters on 3-story enameled front. AMERICAN ROLLING MILL CO. *Steel*, **99**, 17 (July 27, 1936).—Porcelain enameled sheets, stainless steel, and luminous tubing are combined to make a 3-story store front. H.E.S.

Theory and practice of pickling in enamel industry. ANON. *Glashütte*, **67** [23] 374–76 (1937).—A theoretical and practical explanation of pickling iron with sulfuric and hydrochloric acid solutions is given together with a table showing the quantity of iron dissolved by hydrochloric solutions of different concentrations. M.V.C.

Traveling stock rooms utilize space above working areas. D. F. SMITH. *Steel*, **99**, 51–53 (Oct. 26, 1936).—Incoming steel is conveyed on gravity roll conveyers through the machine shop as it is processed. In the vitreous enamel department chain conveyers and belt conveyers carry the work through spray booths, drying ovens, and continuous ovens. Another chain conveyer, 1200 ft. long, acts as a moving stockroom for outer cases after they leave the finishing department. The assembly conveyers are of the flat type, 24 in. wide, in three parallel lines with a total length of

1200 ft. The transfer conveyer carries the cabinets over the plant yard railroad tracks, a distance of 600 ft., to the warehouse. Illustrated. H.E.S.

Treating and cleaning enameled ware. R. ALDINGER. *Glashütte*, **67** [35] 552–54 (1937).—The use of sand and acids for cleaning enameled ware should be avoided. Hot water with soda or soap is a suitable cleansing agent, and no agent which will attack the enamel chemically or scratch it should be used. Only cleansing powders which are softer than the enamel itself can be used. M.V.C.

Vitreous enamel applied to copper. ANON. *Steel*, **99**, 59 (Sept. 21, 1936).—Enameled copper is a new engineering and architectural material as a result of a recent research program sponsored by the Copper and Brass Research Association at the Battelle Memorial Institute, Columbus, Ohio. Enameled copper is somewhat more expensive than enameled steel but not so stiff or rigid and has marked advantages for certain applications. H.E.S.

BOOK

Manual of Porcelain Enameling. Edited by J. E. HANSEN. Enamelist Publishing Co., Cleveland, 1937. 520 pp. Price $5.00. This is the latest and most complete textbook ever issued on the subject. It contains last-minute technical and practical information on all phases of porcelain enameling. Each chapter is the work of a specialist who has devoted the better part of his life to the problems under discussion. The new volume makes use of some material from The Advanced Technique of Porcelain Enameling (*Ceram. Abs.*, **11** [6] 350 (1932)), but most of the text is new, made necessary by the many recent developments and improvements in the industry. Tables of useful data are included together with an Enameler's Dictionary, a complete glossary of the technical jargon of laboratory, smelter, mill room, and furnace room. Chapter headings are as follows: history of the art, design and fabrication of sheet-iron parts, cast iron for enameling purposes, preparation of metal surfaces, enamel mill room practice, mill additions, water and air supplies for enameling plants, application of enamel, drying, brushing, enameling of signs, enameling of hollow ware, burning, inspection, decorative effects, shop troubles, process control, muffle furnace atmosphere and temperature gradient effects, fuels and their combustion, enamel shop construction, and equipment and layout.

PATENTS

Degreasing of metal articles. J. H. ROBERTS, T. H. MEREDITH, AND IMPERIAL CHEMICAL INDUSTRIES, LTD. Brit. 475,056, Nov. 24, 1937 (May 11, 1936).

Enameling. KARL KAUTZ (Republic Steel Corp.). U. S. 2,099,340, Nov. 16, 1937 (June 28, 1934). In the process of enameling ferrous sheet metal the steps comprise heating the metal in an oxidizing atmosphere to form a smooth, firm, oxide scale thereon, heating the oxidized metal in a reducing atmosphere to remove the oxygen and provide a layer of carbon-free iron on the base metal, thereafter working the metal to the desired texture and shape, and enameling directly to the prepared surface of the base metal whereby an improved bond results with an absence of reboiling.

Enameling furnace. J. L. MCFARLAND (General Electric Co.). U. S. 2,100,222, Nov. 23, 1937 (Sept. 23, 1936). A furnace having a heat-transfer section comprising superposed chambers, means for supporting and moving material therein having different temperatures in the different chambers, and a baffle separating the chambers comprising spaced horizontal plates and a plate spaced vertically therefrom and overlapping the plates for preventing dirt from falling from the upper chamber into the lower chamber but providing a free passage for the exchange of the atmosphere in the chambers.

Flash welding. N. R. STANSEL (General Electric Co.). U. S. 2,100,880, Nov. 30, 1937 (Jan. 2, 1936).

Preparing metal for enameling. G. W. MCGOHAN (American Rolling Mill Co.). U. S. 2,101,950, Dec. 14, 1937 (March 21, 1934); continuation of application June 13, 1933. A process of preparing iron or steel for vitreous enameling consists in coating the metal with a heat-decomposable salt of an adherence-enhancing metal, heating the metal to decompose the salt and form a thin coating of the adherence-enhancing metal alloyed with the iron or steel, and acid treating the product, the metal being nickel.

Vitreous enameling process. H. F. GILBERT (Gibson Electric Refrigerator Corp.). U. S. 2,101,616, Dec. 7, 1937 (substitute for application Aug. 3, 1933; this application Feb. 23, 1937). The process of vitreous enameling comprises milling a mass of enamel frit, opacifying agent, setting-up agent, and water, whereby the mass becomes heated and aërated, aging the resulting mixture for an extended period to cool it and remove air, thus producing an enamel slip of a predetermined viscosity, dipping articles to be coated into the slip, the temperature of the slip being directly controlled throughout the active life thereof to prevent a temperature change after the completion of the aging operation of more than 25°F, and maintaining the temperature thereof after aging below a maximum of 85°F, whereby the predetermined viscosity is maintained substantially constant.

Zirconium oxide opacifier and method of making. C. J. KINZIE (Titanium Alloy Mfg. Co.). U. S. 2,100,337, Nov. 30, 1937 (June 22, 1935). The method of making a vitreous enamel white opacifying composition comprises electrothermally converting, without fusion, zirconium-containing materials mixed with a carbonaceous reducing agent to elimination of substantially all the silicon therein, heating the resulting product to oxidation to form a product composed chiefly of zirconium oxide but also containing undesired impurities, then heating the product to about 950° to 1050°C in the presence of chlorine to reduce and volatilize the impurities, including substantially all the iron and titanium, and finally calcining the residual product to eliminate substantially all chlorides therefrom.

Glass

Adsorption of gases by glass walls: XIV, CO_2 and Jena glass. Kinetics of adsorption. V. ALEIXANDRE. *Anales Soc. Espan. Fís. Quím.*, **34**, 315–19 (1936); abstracted in *Physik. Ber.*, **17** [21] 2001 (1936).—The adsorption of CO_2 by Jena glass is about 2.01×10^{-5} cc. at 16°C, which is about the same as for ordinary glass. For Parts **IX, XII–XIII** see *Ceram. Abs.*, **15** [3] 106 (1936).

M.H.

Artistic tasks in the glass industry. W. WAGENFELD. *Glastech. Ber.*, **13**, 413–16 (1935); *Jour. Soc. Glass Tech.*, **20** [77] A53 (1936).—Reference is made to the exhibition of German products in England in 1915 and to the powerful "Deutsche Werkbund" (German Work Confederation) of industrialists, merchants, artists, handworkers, and museum directors. Extracts are quoted from English publications to show that good quality of merchandise is appreciated. Rationalization and price cutting has caused a deterioration in quality, and reference is made to "public taste." In the hollow glassware industry, there are two faults: (1) too little time is spent in the creation and execution of new models, and (2) the translation of designs into material is mechanical and lifeless. The designer should know something of works methods. A firm is not to be judged by the number of its products and its display of samples, but by the quality of its ware, *i.e.*, the fineness of the material used, the value of the work, and the general characteristic impression of its products.

Attempts to determine chemical resistance of glass according to the method of radioactive indicators. V. G. VOANO. *Optiko-Mekh. Prom.*, **7** [4] 16–17 (1937); abstracted in *Chem. Zentr.*, **1937, ii,** 2733.—It is impossible to determine quantitatively the progress of attack of moist air in glasses containing Ra by determining the "volume of emanation" set free, because the gel formed on the glass surface adsorbs part of it. M.V.C.

Batch materials improving the properties of glass. ANON. *Sklarske Rozhledy*, **12**, 41–45 (1935); *Jour. Soc. Glass Tech.*, **20** [77] A185 (1936).—Data are quoted, mostly from foreign papers, on the effect of small additions of B_2O_3, ZnO, etc., on the physical properties of glass. See *Ceram. Abs.*, **16** [3] 86 (1937).

Behavior of glass under various mechanical processes. B KINDT. *Glastech. Ber.*, **13**, 245–47 (1935); *Jour. Soc. Glass Tech.*, **20** [80] A295 (1936).—K. gives a brief account of some tests on the mechanical working of glass in the bath, using hardened metal tools, and the final machining, using a precision grinding machine.

Behavior of tank brick at the glass surface during dissolving. K. O. HAHNEL. *Sprechsaal*, **70** [31] 402–403 (1937).—H. reviews present-day studies of the dissolving of tank brick in contact with the molten glass surface. References. M.V.C.

Beryllium oxide as a component of glass. A. MAURI. *Ind. Vetro & Ceram.*, **9** [5] 106–10 (1936).—The Italian deposits of beryllium oxide are described. The papers of C. F. Lai and A. Silverman (*Jour. Amer. Ceram. Soc.*, **11** [7] 535–41 (1928); **13** [6] 393–96 (1930)) and H. Insley are outlined. F.E.V.

Calculation of filters for color temperature conversion. K. S. WEAVER. *Jour. Optical Soc. Amer.*, **26** [9] 339–42 (1936).—A chart is given which is useful in solving several problems in the design and examination of color-temperature altering filters. A.P.

Change in Ensz method for analysis of gases occluded in bubbles present in glass. V. G. VOANO. *Optiko-Mekh. Prom.*, **7** [2] 14–15 (1937); abstracted in *Chem. Zentr.*, **1937, ii,** 2242.—The absorption of gases from bubbles found in glass in a measuring bulb with glycerin as recommended by Ensz is unsatisfactory. It is better to use small pipets filled with an absorption medium into which gas bubbles are absorbed. The absorption media are (1) 5 g. KOH dissolved in 4 cc. H_2O and 8 cc. glycerin for CO_2; (2) pyrogallol dissolved in HNO_3 and alkalized KOH for O_2; (3) saturated solution of $FeSO_4$ acidified with H_2SO_4 for NO. CO is also absorbed as indicated by Ensz. The gas residue is regarded as N_2. M.V.C.

Chemical reactions of water adsorbed on glass. H. E. BENT AND G. J. LESNIK. *Jour. Amer. Chem. Soc.*, **57**, 1246–50 (1935); *Chem. Abs.*, **29**, 6122 (1935).—The color change resulting from the reaction of an ether solution of Na triphenylmethyl with H_2O was used to measure the H_2O remaining adsorbed on glass that was first treated with hot chromic acid, rinsed with distilled H_2O, and dried by evacuation either at room temperature or at 304°. The results indicate the removal by the Na triphenylmethyl of an adsorbed film 5 mols. thick if evacuation was at room temperature and 2 mols. thick if at 304°. The vapor pressure of H_2O in equilibrium with Na triphenylmethyl is estimated to be between 10^{-12} and 10^{-20} mm. of Hg.

Detection of small quantities of boric acid in glass. H. GRAVESTEIN AND A. W. F. MIDDLEBERG. *Mikrochemie, Festschr. von Hans Molisch*, **1936**, 154–63; *Chem. Abs.*, **31**, 4463 (1937).—In making a German incandescent light, 0.05 to 0.1 mg. of borax from the solder used is left in the lamp. It is possible to detect the B by fusing with Na_2CO_3 and evaporating with pure HCl. During the evaporation, a sublimate of H_3BO_3 can be obtained if suitable precautions are taken.

Determining resistance to thermal shock of glass. K. MAYER AND H. STARNSKY. *Sprechsaal*, **70** [32] 414 (1937).—Resistance to thermal shock of a series of glass rods was studied according to known methods. The resistance to thermal shock decreases with the increase of the coefficient of expansion. M.V.C.

Dolomite as raw material in the glass industry. ANON. *Allgem. Glas- & Keram. Ind.*, **28** [7] 3 (1937).—The use of dolomite as raw material in glass has considerably increased, owing to the beneficial action of magnesium oxide as a glass constituent. MgO improves the quality of glass by reducing its coefficient of expansion and increasing its mechanical and chemical resistance; it affords the possibility of lowering the working temperature of the metal and imparts brightness to the glass. Substitution of MgO for CaO in glass containing initially SiO_2 74, Na_2O 16, and CaO 10% in industrial practice decreases the devitrification temperature about 30°C for every percentage of MgO present in the melt and reduces the rate of crystal growth. The beneficial influence of MgO is ascertained both by technical and scientific investigations. Deposits of high-grade dolomite of low iron-oxide content are available in Czechoslovakia. R.W.D.

Durability of soda-lime-magnesia glass. K. TABATA, T. YOKOYAMA, AND T. KOBAYASHI. *Jour. Japan. Ceram. Assn.*, **43**, 801 (1935); *Jour. Soc. Glass Tech.*, **20** [77] A63 (1936).—The durability in water of the glass $Na_2O(1-x)$-CaO, xMgO, $y$$Al_2O_3$, $5.3SiO_2$, in which $x = 0$ to 1.0 and $y = 0$ to 0.2, was determined by the powder method at 95° and at 170°. When y was constant, the durability decreased with the increase of x, and when x was constant the durability increased with the increase of y. The glass

which had greater durability at 95° also had greater durability at 170°.

Effect of alumina on optical constants and chemical resistance of heavy baryta crown glass of the L-24 type. V. V. Gavrilov and A. v. Samus. *Optiko-Mekh. Prom.*, **7** [4] 1-5 (1937); abstracted in *Chem. Zentr.*, **1937**, ii, 2415.—The chemical resistance of heavy baryta crown glass of the composition 33.6 SiO_2, 13.6 B_2O_3, 46.6 BaO, 3.0 ZnO, and 3.2% Al_2O_3 is greatly increased by increasing the alumina content to 15%; the index of refraction and that of dispersion, however, are little affected. The presence of SrO increases the refractive index without changing dispersion. M.V.C.

Effect of batch and moisture on melting and working of glass. Klaus Kügler. *Glashütte*, **67** [30] 467–70 (1937).—This discussion is based on present-day literature, especially the studies of Turner and his collaborators and those of Gehlhoff and Thomas; the results of these investigations are compared and analyzed as to the effect of water on glassmelting. The question of the action of water steam as an acid or "contact substance" has not been determined. M.V.C.

Effect of chemical pretreatment of glass surface on the silvering process. T. T. Neuman and B. N. Moskvin. *Optiko-Mekh. Prom.*, **7** [4] 8–10 (1937); abstracted in *Chem. Zentr.*, **1937**, ii, 2580.—A yellow-brown Ag layer consisting of separate small crystals is formed shortly after silvering and pretreating the glass surface with $SnCl_4$, $TiCl_4$, $Th(NO_3)_4$, $AlCl_3$, $Pb(CH_3COO)_2$, methylene blue, or water; when $SnCl_2$ is used, a very thin blue layer appears on the surface which promotes the formation of mirrors. M.V.C.

Effect of conditions of polishing and composition of polishing media on rate of polishing of optical glass. B. N. Moskvin. *Optiko-Mekh. Prom.*, **7** [1] 6–9 (1937); abstracted in *Chem. Zentr.*, **1937**, ii, 2238.—Various glasses show different polishing properties. The increase of the specific pressure accelerates polishing; the effect of speed with which the glass is polished (number of revolutions of the roller) could not be determined. M.V.C.

Effect of direction of drawing on the tensile strength of drawn plate glass. W. Mangler. *Z. Physik*, **93**, 173–76 (1935); *Jour. Soc. Glass Tech.*, **20** [77] A69 (1936).—The ultimate strength, Z_0, is calculated from the practical strength, Z, by the equation $Z = Z_0(1 - s/q)$, where s = area of "mirror" cross-section of fracture and q = full cross-sectional area of specimen. This equation is valid for the limits $s/q = 0.05$ to 0.40. Specimens of rectangular cross-section were ground and polished from drawn plate glass, having their lengths parallel and normal to the direction of drawing.

Effect of heat treatment on mechanical strength of transparent quartz glass. M. A. Bezborodov, N. D. Zav'yalov, and A. A. Sokolova. *Zhur. Tekh. Fiz.*, **5**, 1103–1108 (1935); *Chem. Abs.*, **30**, 8544 (1936).—Quartz-glass rods 2 to 3 mm. in diameter, having a bending strength of 11.3 kg./sq. mm., were heated for 1 and 3 hr. at temperatures of 1100°, 1300°, and 1500° (1 hr.). The temperature factor has a greater influence on the mechanical strength than time of heat treatment.

Effect of heating the liquid bath on the thermal strength of glasses. H. Schönborn. *Sprechsaal*, **70** [23] 301–302 (1937).—Thermal resistance or "chilling strength" of hollow glasses is usually determined by heating glasses filled with paraffin or other materials to a certain temperature and then chilling them with cold water; the temperature is gradually increased after each test. A method for determining thermal resistance of glass is described in which the difference in temperature remains constant but the chilling is repeated several times. If glass is heated in oil before chilling, the values of strength obtained are much higher than those obtained when heating it in water. This difference in stability is due to a thin oil film remaining on the glass surface which greatly lowers the rate of cooling as well as the maximum of tensions on the glass surface occurring during chilling. M.V.C.

Effect of rate of loading and torsional deformation on tensile strength of glass rods. G. Apelt. *Z. Physik*, **91**, 336–43 (1934); *Jour. Soc. Glass Tech.*, **20** [77] A65 (1936).—The effect of rate of loading on the tensile strength at room temperature of glass rods drawn from Thüringian apparatus glass is shown. The ultimate strength, Z_0, is defined by the equation $Z = Z_0(1 - s/q)$, where Z = practical strength, q = cross-sectional area, and s = area of the "mirror" portion of the fracture.

Electric melting furnaces in the glass industry. V. V. Čtvrtký. *Sklarske Rozhledy*, **12**, 88–90 (1935); *Jour. Soc. Glass Tech.*, **20** [77] A176 (1936).—A general description is given of a new electric glassmelting furnace with heating elements on the inside face of the crown. The batch is automatically carried through a preheating and sintering chamber, from which it passes, dust free, into the actual melting area. No description is given of the working tank.

Electric transport through phase boundaries: System I [glass-gas or vapor], (2) electrolytic introduction of hydrogen, nitrogen, and potassium into a glass diaphragm, and the electrolytic transfer of sodium through the glass diaphragm. C. Stüber. *Z. Physik. Chem.*, **172**, 401–28 (1935); *Jour. Soc. Glass Tech.*, **20** [77] A9 (1936).—A direct current (discharge tube) flowed from an anode situated in the vapor, through a glass diaphragm, to the cathode. The positive ions produced in the vapor were thus introduced into the glass, replacing the alkali ions wandering out of the unipolar conducting glass. Experiments were made, using the following gases and vapors: He, O_2, CO_2, H_2, N_2, HCl, NH_3, C_6H_6, CCl_4, Na, K, Cd, and Hg. Results were as follows: (1) For all electrolysis of the glass, using gas or metallic vapor anodes, Faraday's laws for the cathodic removal of sodium or potassium from the glass were obeyed within the limits of experimental accuracy. (2) The cations Na^+, K^+, and H^+ from the gas or vapor phase were electrolyzed into the glass from the anode space. (3) Nitrogen also wandered into the glass, but it was not known how it was retained. (4) The behavior of mercury and cadmium vapors relative to their introduction into the glass was not decided with any certainty. (5) Attempts to introduce lithium vapor failed, owing to the resultant destruction of the glass. (6) For the materials helium, oxygen, carbon dioxide, and carbon tetrachloride, no stopping point for the electrolytic introduction was found. (7) Hydrogen chloride, ammonia, and benzine were decomposed by the electric dis-

charge current. The drop in pressure observed in the anode space during the passage of the current was partially attributed to the penetration of H^+ ions (into the glass). (8) For all glass electrolysis not connected with the introduction of cations, on the anode side of the glass were formed $SiO_3(SiO_3)_x$ radicals which at high temperatures were decomposed into $SiO_2(SiO_2)_x + {}^1/_2O_2$. The increase in pressure observed in the anode space during the electrolysis of helium, oxygen, and carbon dioxide was due to this process. The formation of water which appeared in the hydrogen experiments could be attributed to a decomposition of the hydrogen replacement silicates into water and $SiO_2(SiO_2)_x$ and then also by the direct decomposition of the $SiO_3(SiO_2)_x$ radicals into $SiO_2(SiO_2)_x + {}^1/_2O_2$; in the latter case water was formed in the gas (H_2) space. The fact that the introduction of hydrogen exceeded the theoretical amount predicted by Faraday's laws by about 10% was explained by the chemical reaction of active hydrogen with the SiO_2 of the glass. (9) It was shown that the disappearance of gases could not be explained by diffusion, occlusion, or "clean-up" phenomena. (10) For sodium vapor it was possible to transport sodium (for the first time) electrolytically from the anode space, through the glass, into the cathode space. (11) With few exceptions, the change in the glass resistance during electrolysis was measured. (12) With the help of sodium or potassium vapor electrolysis, sodium or potassium mirrors were produced in photocells and were melted onto the cathode space of the electrolysis vessel. (13) The sensitiveness of these cells was experimentally determined. **System II [glass-molten metal (mercury)]. System III [glass-molten salt (silver nitrate)].** ERICH MANEGOLD AND CAMILL STÜBER. *Z. Physik. Chem.*, **A173,** 321–44 (1935); *Chem. Abs.*, **29,** 7816 (1935).—A direct current was passed through a highly heated glass diaphragm that had been coated with Hg or with molten $AgNO_3$. The changes in the anodic charge of the glass and their effect on the electrical properties of the glass diaphragm were as follows: by electrolysis of the glass between liquid Hg electrodes, dark brown deposits formed just below the surface of the glass and were identified as Pt. During the electrolysis, measurements were made of the course of the current-time curve with constant voltage, the polarization tension, the voltage curve, and the appearance upon interruption of the electrolysis. During electrolysis of glass between molten $AgNO_3$, a migration of Ag ions is manifested by a yellow coloring of the glass. The depth of penetration can hardly be measured. Ag-containing Duran glass shows an intense yellow fluorescence under the Hg arc lamp. With increasing temperature the color darkens but the fluorescence decreases. Previous experiments on system I (glass-gas) were considered in calculating the specific resistance of the anode layer. The thickness of the charge on the anode side of the glass was measured, which made possible the calculation of the percentage of migratory Na in the glass. Na ions are replaceable by Ag or H ions in the transport of current.

Evolution of gases from glass under the influence of a high-frequency discharge. V. I. ROMANOV AND N. A. TZVETKOV. *Zhur. Tekh. Fiz.*, **5,** 996–99 (1935); *Chem. Abs.*, **30,** 8544 (1936).—Tubes with and without electrodes were subjected to high-frequency discharge ($\lambda = 100$ m.). In a short time (5 to 8 min.) CO_2 and H_2 spectra appeared, soon becoming so intense as to obscure other spectra. Probably the glass decomposes as a result of the high temperature.

Form and decoration with respect to industrial applications. TECHNICAL COMMITTEE IV OF THE DEUTSCHE GLASTECHNISCHE GESELLSCHAFT. *Glastech. Ber.*, **13,** 261 (1935); *Jour. Soc. Glass Tech.*, **20** [77] A53 (1936).—Photographs of work suitable for industrial use which has been done in the Stuttgart School of Art under von Eiff are shown. These illustrate new forms, new technical applications, the influencing and change of form by the method of working, and the adaptation of existing designs to cutting and grinding. The important part played by the enthusiasm of the craftsman for his art is stressed.

Fused silica in the laboratory. BURROWS MOORE. *Chem. & Ind.*, **56** [42] 919–21 (1937).—Fused silica is a glass of one component, having low thermal expansion, high chemical resistance, high working temperature, low permeability to gases, and high electrical resistance at considerable temperatures. A list of the varieties of general laboratory equipment now supplied in fused silica is given. Other types of special apparatus available include (1) a portable ultra-violet fluorescent unit for the identification of material, (2) a compact three-stage mercury condensation pump, (3) continuous feed-water distillation apparatus, (4) microanalytical apparatus, (5) mercury purification apparatus, (6) tubular immersion heaters, and (7) electrically heated hot plates of circular form. See *Ceram. Abs.*, **16** [11] 333 (1937). G.R.S.

Gas heating and heat transfer in glassmelting tanks. W. SCHNEEKLOTH. *Glastech. Ber.*, **13,** 185–95 (1935); *Chem. Abs.*, **29,** 6377 (1935).—The distribution of the hot combustion gases over the glass bath is correlated graphically with the flame direction for the tank studied. The results do not agree with the conclusions of Trinks on the importance of a luminous flame for heating through the depth of the glass. There is insufficient knowledge of the radiation properties of glasses at high temperatures. 12 references.

Glass from ancient Egypt. H. DE MORANT. *Nature* [Paris], No. 9, pp. 385–89 (1937).—Glass specimens dated or signed by their maker are scarce; the most ancient pieces known were manufactured about B.C. 3500 and reproduce various types of beads. M. describes the most remarkable specimens now in museums. Chemical composition and manufacturing processes are given. R.W.D.

Glass block in container plant. OWENS-ILLINOIS GLASS CO. *Steel*, **99,** 34–35, 61 (Oct. 5, 1936). H.E.S.

Glass brick: thermal conduction. E. H. BOOTH. *Jour. Proc. Roy. Soc. New South Wales*, **70,** 452–55 (1936).—Hollow glass brick are built into walls with ${}^1/_4$-in. mortar joints. The rate of heat transfer (apart from direct radiation) is 0.7 B.t.u./sq. ft. wall face/hr./1 °F difference in temperature between opposite faces. H.H.S.

Glass as building material. ANON. *Sklarske Rozhledy*, **12,** 1–5, 24–28 (1935); *Jour. Soc. Glass Tech.*, **20** [77] A222 (1936).—General formulas of the strength of materials are applied to a glass to calculate the strength of a glass sheet as a function of its dimensions, the trans-

mission of heat through window glass, and the absorption of solar radiation.

Glass for chemical apparatus. ERIC PRESTON. *Chem. & Ind.*, **56** [42] 921–22 (1937).—Thermal resistance should accompany increased chemical durability of glass. Properties of Pyrex brand glasses are a typical example. Average initial rates of attack under different conditions are given in a table. G.R.S.

Glass decoration. TECHNICAL COMMITTEE IV OF THE DEUTSCHE GLASTECHNISCHE GESELLSCHAFT. *Glastech. Ber.*, **13**, 259–61 (1935); *Jour. Soc. Glass Tech.*, **20** [77] A53 (1936).—The most important work of Committee IV was the improvement of industrial glassware, in particular hollow ware, in form, color, and taste and the fostering of collaboration between artists and manufácturers. All possible steps are to be taken to attain this aim by publicity. Present-day glass products are critically considered. The cry of "novelty at any price" is a danger to the culture of the people. It is pointed out that the manufacturer must help to stimulate an artistic development which will influence the market more actively than hitherto, and then his dependence on the buying public will not be abused.

Glass defects and their removal in Fourcault glass. ERNST FISHER. *Sprechsaal*, **70** [38] 482–84 (1937).—The following defects, their causes, and means of eliminating them are briefly dealt with: (1) formation of small devitrification crystals on the glass surface, (2) warped glass panes, (3) defects due to a too rapid drawing of glass, (4) devitrification, (5) streaks and striae, (6) defects of nozzles, (7) glass bubbles, and (8) glass seeds and stones. M.V.C.

Glass grinding and cutting tools. SUB-COMMITTEE OF TECHNICAL COMMITTEE III of the DEUTSCHE GLASTECHNISCHE GESELLSCHAFT. *Glastech. Ber.*, **13**, 258 (1935); *Jour. Soc. Glass Tech.*, **20** [77] A55 (1936).—Silicon carbide wheels are best for glass; their porous structure holds the water better. Ceramic bonded wheels are mostly used, but silicate bonded wheels are employed in surface grinding. Bakelite bonded wheels are good for large high-speed wheels and for thin disk wheels. It is not possible to classify the working of glass by the means available for various kinds of steel. Large wheels can be built segmentally. Dry grinding is dangerous to health on account of the dust raised.

Glass as industrial material in the vacuum technique. W. ESPE AND J. BÖHME. *Feinmechanik & Präzision*, **45**, 73–76, 101–104, 115–18 (1937); abstracted in *Chem. Zentr.*, **1937, ii**, 2239.—Glass used in the vacuum technique must (1) be free from tensions, (2) possess electric properties, (3) be permeable to radiation, and (4) have a certain chemical resistance. Data on 81 glasses and a literature index are given. M.V.C.

Glass industry. ANON. *Index* [New York Trust Co.], **15** [10] 205–13 (1935).—This is a general discussion of the development of the glass industry, particularly in the U. S., uses of glass in modern life, and data on the production and value of various glassware manufactured in the country. M.V.C.

Glass industry and history. HANS SCHULZ. *Glashütte*, **67** [22] 343–46 (1937).—A general discussion of the development of glassmaking and its relationship to the history of the world is given. M.V.C.

Glass silk in heat conservation. ANON. *Fuel Economist*, **10**, 596–99 (Nov., 1934); *Jour. Iron & Steel Inst.* [London], **131** [1] 327 (1935).—Brief particulars are given of the production and properties of glass silk and its use as an insulating material. See *Ceram. Abs.*, **14** [11] 274 (1935); **15** [5] 148 (1936).

Glass sintering in the manufacture of glass apparatus. S. E. KRASIKOV AND D. P. IVANOV. *Jour. Opt.-Mech. Ind.* [U. S. S. R.], **1935**, No. 10, p. 20; *Jour. Soc. Glass Tech.*, **20** [79] A190 (1936).—A description is given of the methods of the construction of glass apparatus requiring sintered portions as an integral part of the apparatus.

Glasses containing iron oxide: IV. K. FUWA. *Jour. Japan. Ceram. Assn.*, **43**, 806–11 (1935); *Jour. Soc. Glass Tech.*, **20** [77] A20 (1936).—In soda-lime-silica and potash-lime-silica glasses, when the total iron oxide content is small, the color in the potash glasses is lighter than in corresponding soda glasses. With higher total iron oxide content (about 0.5% and above) there is little distinction between the colors of similar glasses of the two types. The determination of light transmissions of the glasses supported the visual examination. For Parts **V–IX-b** see *Ceram. Abs.*, **16** [3] 86–87 (1937).

Grinding and polishing glass. HANS SCHULZ. *Glashütte*, **67** [39] 607–609 (1937).—S. gives a general description of grinding and polishing of glass and materials used. M.V.C.

Halogens in transparent glass. ANON. *Keram. Rundschau*, **45** [8] 84–85 (1937).—Although halogens have been detected in many old glazes, they have seldom been used in commercial quantity for glassmaking. Halogens are opacifying agents; the temperature of decomposition of their compounds is variable; they destroy refractory material. Some compounds (fluosilicates, chlorates) decompose readily, facilitate melting and plaining, and do not interfere with glass coloration. Others (NaCl, NaF, Na_3AlF_6) are decomposed at higher temperature and influence glass quality. Fluorspar is a link between both groups. The formation of volatile iron halides and of $SiOF_2$ is briefly discussed. The plaining process of halogen derivatives and the behavior of fluorspar are described. F.E.V.

Historical glassware. W. DEXEL. *Glashütte*, **67** [29] 455–58 (1937).—A brief description of the gradual development of the manufacture of glassware is given. Illustrated. M.V.C.

Influence of temperature on viscosity of glasses melted by the "Lenzos" works. M. M. SKORNIAKOV, A. S. GORALNIK, AND K. S. EVSTROP'EV. *Jour. Opt.-Mech. Ind.* [U. S. S. R.], **1935**, No. 7, p. 3; *Jour. Soc. Glass Tech.*, **20** [79] A228 (1936).—The viscosity of optical glasses from 890 to 1400° was determined. All the glasses investigated, with the exception of two heavy baryta crowns at viscosities lower than 10^4 poises conformed to the equation, $\eta = Ae^{a/T}$, where η is viscosity, T, absolute temperature, and A and a, constants for the given substance. Heavy baryta crowns gave a break of the curve, $\log \int \left(\frac{1}{T}\right)$, at temperatures of 1100 to 1200°. A similar break was ob-

tained by E. on the curve of the log of electric conductivity. The authors stated that I. V. Grebenshchikov explained anomalies in the physical and chemical properties in glasses with high barium content by the dissociation of barium silicate, occurring at about 1200°. See "Change—," *Ceram. Abs.*, **15** [10] 296 (1936).

Kjeldahl flasks and other vessels from arsenic-free glass. GEORG LOCKEMANN. *Z. Anal. Chem.*, **103**, 81–82 (1935); *Chem. Abs.*, **30**, 653 (1936).—A new glass made by the Jena Glaswerke Schott & Gen. and marked "arsenfrei" has proved suitable for all digestions with H_2SO_4 or solutions of bases without danger of getting appreciable As into the solution. The new glass, because no As_2O_3 is used in its manufacture, contains air bubbles but is not fragile, and no trouble results from heating over a free flame. E.J.V.

Manufacture of glass blanks for spectacles. A. THURET. *Céram., Verrerie, Email.*, **3**, 127–29 (1935); *Jour. Soc. Glass Tech.*, **19**, A207 (1935).—A typical glass composition is SiO_2 72, CaO 13, and Na_2O 15%. The method of production of the blanks is outlined, and coloring agents used in sun-protecting glasses are given. Glasses absorbing ultra-violet light contain cerium oxide and traces of didymium and lanthanum oxides.

Methods of control in glass silvering practice. J. B. *Glaces & Verres*, **52**, 13–16 (1937).—For the determination of the thickness of the silver layer deposited onto the glass sample, the amount of silver deposited from solutions containing 2.5 g. of $AgNO_3$ per liter (1 liter of solution being spread over 1 sq. m. of glass surface) is plotted against time. The curve (1) so obtained shows that the silver layer, after 6 minutes' exposure, remains practically constant to the action of the reagents and that the rate of increase of the deposit thickness (in terms of time) progressively diminishes. The silver layer, approximately 110 mμ thick, is more or less transparent, and for high-grade mirrors, the application of several successive deposits is recommended. The thickness of the second layer is a little less than that of the first layer, but its representative curve is similar to (1), and the yield decreases for every subsequent deposit. Increasing the concentration of the silver nitrate solution, in order to reduce the number of layers, did not prove to be efficient. The thickness of the silver layer may be determined approximately (1) by comparison of its transparency (bluish tint) with that of standard samples; (2) by means of a photoelectric cell (the radiations emitted by any source of light are first passed through the silver layer before they strike the photoelectric cell; the microammeter record is proportional to the amount of light that has not been absorbed by the silver deposit); and (3) by the brightness of the outer surface of the silver layer, which depends on the thickness of the deposit, *i.e.*, the thinner the deposit, the brighter is its appearance. In addition to simple inspection with the naked eye, the photoelectric process is also applicable. In this case, the emitted radiation falling on the outer surface of the silver layer (the surface not in contact with the glass), under suitable incidence, is next reflected before reaching the photoelectric cell. These methods of checking the thickness of the silver deposit are simple and may be of valuable assistance to persons interested in glass silvering. R.W.D.

Microchemical analysis of glasses: VII, Detection and determination of gold. W. GEILMANN AND O. MEYER-HOISSEN. *Glastech. Ber.*, **13**, 86–89 (1935); *Brit. Chem. Abs.-B*, **55** [25] 543 (1936).—The glass (1 g.) is fused with 5 g. of a 1:1:1 mixture of $KNaCO_3$ + borax glass + $Pb(OAc)_2$. The Pb bead formed is oxidized, and the Au remaining is determined micrometrically or colorimetrically (in its $AuCl_3$ solution) with *o*-tolidine. **VIII, Determination of arsenic in glasses.** *Glastech. Ber.*, **13**, 420 (1935); *Chem. Abs.*, **30**, 1529 (1936).—In determining As in glasses the authors recommend its volatilization as arsine in the usual way and determination of the latter. Amounts up to 0.025 mg. are obtained colorimetrically with $HgCl_2$ paper, while for amounts from 0.025 to 10 mg., gravimetric determination of the reaction product of the arsine with $HgCl_2$ solution is useful. Total As is obtained by alkaline decomposition of the glass, while quinquevalent As can be determined by decomposition of the glass with HF-H_2SO_4 mixture and fuming off of the As_2O_3. The trivalent As is obtained by difference. For Parts **V–VI** see *Ceram. Abs.*, **14** [4] 90 (1935).

Muffle leers and leers with direct firing. ZSCHACKE. *Glashütte*, **67** [35] 549–52 (1937).—After discussion of the operation and merits of muffle leers and leers with direct firing, Z. concludes that the former are superior to the latter and do away with the majority of defects found in leers with direct firing. M.V.C.

Oil firing in the glass industry. RUDOLF HOHLBAUM. *Glashütte*, **67** [25] 403–406; [26] 418–20; [27] 431–33; [28] 442–44 (1937).—The suitability of oil firing in the glass industry and various types of furnaces used are discussed in detail. Illustrated. M.V.C.

Processes occurring in melting heavy baryta crown. V. V. VARGIN AND A. A. KEPELI. *Jour. Opt.-Mech. Ind.* [U. S. S. R.], **1935**, No. 4–5, p. 10; *Jour. Soc. Glass Tech.*, **20** [80] A271 (1936).—The heating behavior of the following batch was studied: sand 26.0 g., H_3BO_3 18.7, Al_2O_3 2.5, $BaCO_3$ 50.5, and ZnO 2.3. Another series of meltings was conducted with batches in which 25% of the barium was introduced as $Ba(NO_3)_2$. The heatings were performed at 400° to 1200°, and the temperature was raised 100° every 4 hr. The loss in weight of all batches was determined every 5 min. during the heatings. The melts obtained were subjected to fractionary chemical analysis by the following solutions: (1) methyl alcohol, (2) hot water, (3) hot solution of NH_4Cl, (4) HCl and then a solution of Na_2CO_3, and (5) HF. In a batch of heavy baryta crown containing $BaCO_3$, barium borate was formed at room temperature during batch mixing, and the presence of moisture promoted its formation. Before a temperature of 400° was reached, all hydrated water was expelled from the H_3BO_3, and at the same time barium borate was formed. The alumina entered the reaction between 700° and 800°. The reactions, with the removal of all CO_2, were completed at 750°. The solution of the sand grains at 1100° required 4 hr. When 90 or 100% of the barium was introduced as $Ba(NO_3)_2$, the reactions connected with the removal of gases again were completed at 750°. See "Effect of steam—," *Ceram. Abs.*, **16** [8] 240 (1937).

Pyrex brand drier tube. F. KRAISSL. *Ind. Eng. Chem., News Ed.*, **13**, 428 (1935); *Jour. Soc. Glass Tech.*, **20** [77] A29 (1936).—A strong, compact, drier tube suit-

able for use with granular chemicals is made from Pyrex brand tubing having a solid partition wall down the center. The bottom of the tube is sealed so as to leave a communicating opening through the partition to either side of the tube. At the top of the tube on either side of the partition, side tubes are sealed. The top of the drier is cut off straight, fire-polished, and closed by a cork or glass stopper. It is possible to absorb CO_2 in one side of the tube and moisture in the other with suitable agents. Modified designs are mentioned.

Raw oil, fuel oil, and coal-tar oil furnaces in the glass industry. RUDOLF HOHLBAUM. *Glashütte*, **67** [19] 301–302; [20] 314–18 (1937).—A brief description of the firing of glass furnaces with raw oil, fuel oil, and coal-tar oil is given. Illustrated. M.V.C.

Reactions of arsenic in glass melts. F. SALAQUARDA. *Sklarske Rozhledy*, **12**, 92–101 (1935); *Chem. Zentr.*, **1936**, I, 1937; *Chem. Abs.*, **31**, 5963 (1937).—According to earlier work, the clarifying action of As can be produced only by the volatile reaction products, As_2O_3 and As, still present in the glass during the refining period, which can be formed in accordance with the reaction $5As_2O_3 \rightarrow 3As_2O_5 + 4As$. Because of the instability of the trivalent compound at high temperature, As_2O_3 can scarcely form compounds with any of the constituents of the glass, and S. assumes that it is contained dissolved in the glass flux, rises to the surface in the sudden evolution of large bubbles, and clears the glass by dragging along many small bubbles.

Recent progress toward correlation of chemical composition, physical constitution, and electrical properties of solid dielectric materials. WILLIS JACKSON. *Jour. Inst. Elec. Engrs.* [London], **79**, 565–76 (1936); *Chem. Abs.*, **31**, 6070 (1937).—The review covers progress during the last ten years. The required insulating properties of dielectric materials may be specified as (1) high resistivity, (2) low power loss in alternating electric fields (allied for many purposes with a high dielectric constant or permittivity), and (3) high electric strength. J. discusses waxes, glasses, textiles, rubber compounds, ceramic materials, etc.

Recognition of breaks in glass resulting from slow loading. K. H. BORCHARD. *Glastech. Ber.*, **13**, 114–16 (1935); *Chem. Abs.*, **29**, 4533 (1935).—Bottles were tested. Breaking always started at some minute flaw in the outer surface. The appearance of the surface formed by the break is similar to that of glass rods broken by loading. Immediately around the starting point is a shiny mirror-like surface. The area of this mirror surface, S, in sq. mm. plotted against the logarithm of the loading velocity, V, in atmospheres/min. gives a curve represented by the equation, $S = S_E \cdot (a - b \cdot \log V)$. The value of S_E is the area of the "unit mirror surface" chosen arbitrarily by B. as the area resulting from a loading velocity of 900 atmospheres/min. Thus $S_{E900} = 18$ sq. mm., and the equation becomes $S = 18(439 - 117 \log V)$. By running such tests on a particular type of ware, it is possible, by measuring the area on a broken surface, to recognize it as the result of slow or fast loading and to find the cause of failure. Curves are given showing the results from an average of 10 tests at the same loading velocity. See "Influence—," *Ceram. Abs.*, **17** [1] 12 (1938).

Relation of the tensile strength of homogeneous glass rod to its cross-section. K. WIRTZ. *Z. Physik*, **93**, 292–97 (1935); *Jour. Soc. Glass Tech.*, **20** [77] A65 (1936).—Tests were made on ground and polished specimens of the Schott No. 21,282 optical glass, loaded at a constant rate of 57 g./sec./mm.^{2}

Research on optical glass. BAUSCH & LOMB OPTICAL CO. *Steel*, **99**, 44 (Nov. 16, 1936).—A broad program of fundamental investigations on the chemistry and physics of glass surfaces to aid in the development of scientific apparatus and ophthalmic instruments has been started at Mellon Institute by the Bausch & Lomb Optical Co. The first studies will be made on the effects of environmental factors on the durability of various types of glasses used in optical instruments. F. L. Jones is in charge of the investigation. H.E.S.

Rock wool. O. STUTZERT. *Glashütte*, **67** [36] 567–69 (1937).—The manufacture of rock wool and its uses and properties are described. Rock wool consists of 35 to 65% SiO_2, 0 to 33% R_2O_3 (chiefly Al_2O_3), 5 to 50% CaO, 0 to 32% MgO, and usually some impurities such as TiO_2, FeO, Na_2O, K_2O, and S. It is obtained by melting rock, usually impure limestone, containing these constituents and from 20 to 30% carbonic acid. M.V.C.

Saint Gobain and the International Exhibition of Paris. J. DANIGRAND. *Clarté*, **10** [8] xvii–xx (1937).—Illustrated. R.W.D.

Seedless glass in continuous tanks. RUDOLF HOHLBAUM. *Glashütte*, **67** [36] 569–70 (1937).—The process of refining glass and its dependence on various factors, such as time, temperature, size of the tank, and refining agents, are discussed. M.V.C.

Selection of color-temperature altering filters. ROGER S. ESTEY. *Jour. Optical Soc. Amer.*, **26** [7] 293–98 (1936).—Characteristics of commercial glasses available for use in the design of special filters are shown diagrammatically. A.P.

Shearing strength of glass rods. MARTIN EICHLER *Z. Physik*, **98**, 280–82 (1935); *Chem. Abs.*, **30**, 2070 (1936).—Reduction of the velocity of loading at higher temperatures causes an increase in the shear strength; previous experiments at room temperature showed the reverse.

Singularities in the variations of the refractive indices of glass at temperatures below 300°. N. TUDOROVSKAYA. *Compt. Rend. Acad. Sci. U.R.S.S.*, [N. S.] **1**, 27–30 (1936).—Investigations on glasses belonging to the binary systems Na_2O–SiO_2 and PbO–SiO_2 demonstrated that, when treating glass at a lower temperature than that of the remelting region, the index of refraction of the glass increases to a certain extent. After subsequent cooling, the curve of the variations of the index of refraction is somewhat lower than that obtained when heating; both curves coincide when the temperature falls. Independently of this, a growth of the refractive index was observed at a constant temperature in all glasses investigated. The time interval in which the refractive index attains a constant value is relatively very small (10 to 15 min.). It does not greatly depend on the temperature and on the composition of the glass. P.B. & E.S.

Structure of phosphorescent glasses. A. SCHLOEMER. *Glastech. Ber.*, **13**, 424–25 (1935); *Chem. Abs.*, **30**, 1529 (1936).—The view of D. Dobischek ("Production—," *Ceram. Abs.*, **15** [10] 299 (1936)) that the phosphorescence of certain glasses examined could be ascribed to a certain

crystalline fine structure is untenable because nothing is known of P in the vitreous condition.

Technical glasses containing boric acid. OSCAR KNAPP. *Glashütte*, **67** [32] 495–99 (1937).—The effect of boric acid in a series of technical glasses is discussed. The characteristics of 18 different types of such glasses are analyzed, and their chemical composition is given in a table. M.V.C.

Temperature dependence of the shearing strength of glass rods. KARL MENGELKOCH. *Z. Physik*, **97**, 46–63 (1935); *Chem. Abs.*, **30** [2] 344 (1936).—Cylindrical glass rods were examined, the cross-section being maintained constant. The temperature dependence of the shear strength was measured between −190° and 545°. A relation is found between the values of the breaking strengths and the size of the mirror-like portion of the torn surface. The theory is discussed.

Tensile strength of plastically deformed glass rods. G. THIERBACH. *Z. Physik*, **91**, 344–48 (1934); *Jour. Soc. Glass Tech.*, **20** [77] A64 (1936).—Rods drawn from lead glass were torsionally deformed at temperatures below the transformation temperature (425°). The ultimate strength, Z_0, is calculated from the practical tensile strength, Z, by the equation, $Z = Z_0(1 - s/q)$, where q = the cross-section of the rod, and s = the area of "mirror" fracture. The limits of s/q are 0.04 to 0.4. The results are as follows:

Temperature of treatment	Deformation for 6 cm. length	Z_0 (kg./mm.²)	s/q, 100	Total number of tests	Angle of fracture
Untreated	0°	9.10 ± 0.79	14.0 ± 11.3	29	14° 30′
292 ± 9.5°	5° in 100 hr.	9.45 ± 0.93	8.9 ± 5.1	37	16° 40′
410 ± 8	12° in 5 min.	9.69 ± 0.97	8.8 ± 5.8	48	16° 30′

Test results on the new apparatus glasses Kavalier "35" and Kavalier "Isis." ANON. *Sklarske Rozhledy*, **12**, 141–44 (1935); *Jour. Soc. Glass Tech.*, **20** [77] A29 (1936).—The Kavalier "35" glass is especially resistant to alkaline solutions, while the "Isis" glass, not quite so resistant chemically, is also a heat-resistant glass. The compositions are not given.

Things worth knowing for coloration of luminous tubes. ANON. *Glas & Apparat*, **18** [11] 103–104 (1937).—The discolorations which luminous tubes (for luminous signs) undergo by temperature changes and the necessity of maintaining continuously the same pure color are explained. The effects of voltage across the lamp, service temperature, and the mixtures of gases applied are discussed. A has the highest resistance against temperature fluctuations (without changing color); Ne should not be used in this case; a small addition of Hg is made. Recently glass tubes with fluorescent and phosphorescent substances in the form of fine powder on the inner wall have been used to convert the invisible ultra-violet rays into visible light. Defects in the tubes and remedies for them are described. M.H.

Time law of extraction of glasses. E. BERGER AND W. GEFFCKEN. *Naturwissenschaften*, **23**, 817–18 (1935); *Chem. Abs.*, **30**, 827 (1936).—Attack of glass by acids, alkalis, water, etc., follows the law $dx/dt = ke^{-Bx}$, in which x is the amount of glass decomposed and t is the time. The same function applies to conductivity change of water during the extraction of glass powder. The law holds as long as the SiO_2 skeleton remains intact; it is generally valid for activated adsorption. This view is supported by the fact that the dependence of k upon acid concentration follows the Langmuir adsorption equation. The same time law also holds for oxidation of metals in air (Tammann), elastic after-effect, volume change, etc., of chilled glass, change of transparency with radiation, and grain growth in cold-worked metals. This is probably due to the fact that the equation represents a special solution of the diffusion problem.

Use of luminous analysis to classify optical glass. E. M. BRUMBERG. *Optiko-Mekh. Prom.*, **6** [11] 3–6 (1936); abstracted in *Chem. Zentr.*, **1937**, ii, 2242.—It is impossible to differentiate glasses by determining their fluorescence or phosphorescence colors only, because some glasses have a different composition but the same colors. A study of 32 optical glasses of the Lenzos Works showed that glasses of similar composition do not show any difference in their fluorescence and phosphorescence colors; the remaining glasses could be differentiated only after determining both types of colors. M.V.C.

Velocity of cooling and heating multilayer safety glass. E. ALBRECHT. *Glastech. Ber.*, **13**, 89–91 (1935); *Brit. Chem. Abs.-B*, **55** [17] 369 (1936).—The testing of safety glass at high and low temperatures is described, and the importance of the rate of temperature change is discussed.

Viscosity of optical glasses containing lead oxide. P. E. FRANK. *Jour. Opt.-Mech. Ind.* [U.S.S.R.], **1935**, No. 8, p. 10; *Jour. Soc. Glass Tech.*, **20** [79] A228 (1936).—The viscosities at different temperatures of glasses containing from 6.32 to 66% PbO were measured. The temperature coefficient of viscosity was not constant but varied with the temperature and glass composition.

Work of W. Weyl on the constitution of glasses. E. BERGER. *Glastech. Ber.*, **13**, 430–31 (1935); *Jour. Soc. Glass Tech.*, **21** [83] A3 (1937).—Changes of the extinction coefficient have been observed at certain characteristic parts of the spectrum of neodymium and praseodymium glasses, and the values, like the thermal expansion curves, lay on two straight lines intersecting at a point where the extinction coefficient showed a correspondingly sudden change. The data of numerous workers, in addition to those now given, proved that the temperature coefficient of extinction or, alternatively, the wave-lengths corresponding to equal probability of excitation changed discontinuously (as did many other properties) at the same temperature, *viz.*, the transformation point. This did not agree with Weyl's conclusions. Weyl concluded that at the transformation point, chemical processes were frozen in, and below T_g, the change of absorption spectrum could be explained only by a process other than chemical. B. concluded that the extinction coefficient varied over the entire temperature range 0 to 750°, changing more rapidly above T_g. According to Zachariasen's view, in solid glass at room temperature, a cation (such as Ni, Cu, Nd, Pr, which existed in the present experiments) embedded in the gaps of the tetrahedral SiO_4 lattice was coördinately bound and surrounded by oxygen atoms. With rising temperature, the disturbing effect of the molecular electric

field surrounding the cation increased, and above T_g, because of the appearance of a new degree of freedom, this disturbing influence increased with a greater temperature coefficient. Such an explanation covered the present transmission observations.

Zinc oxide in the glass industry. ZSCHACKE. *Glashütte*, **67** [31] 479–81 (1937).—The use of zinc oxide in glassmaking and the effect of the German 4-year plan on its consumption by the glass industry are discussed. The replacement of zinc oxide by other materials is also studied.
M.V.C.

PATENTS

Analyzing ocular. L. V. FOSTER (Bausch & Lomb Optical Co.). U. S. 2,101,935, Dec. 14, 1937 (Feb. 28, 1935). An ocular comprises a field lens, the emergent rays from which are not collimated, an analyzing prism, and an eye lens assembly, the eye lens assembly comprising crossed cylindrical lenses so spaced and so related to the analyzing prism and to each other as to form an astigmatic system neutralizing the astigmatism of the prism.

Apparatus for:

Hardening glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Ger. 645,699, June 2, 1937; Cl. 32*a*. 30; *Chem. Abs.*, **31**, 6434 (1937).

Hardening sheet glass by air cooling. ASSUREX "LE ROI DES VERRES DE SÉCURITÉ" MAGNIEN, MONNIER & CIE. AND L. A. E. PETIT. Ger. 646,171, June 14, 1937; Cl. 32*a*. 30; *Chem. Abs.*, **31**, 6434 (1937).

Molding hollow glassware. FIRMA KARL ROSE. Ger. 644,538, May 7, 1937; Cl. 32*a*. 8; *Chem. Abs.*, **31**, 6434 (1937).

Producing striated glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Ger. 645,839, June 5, 1937; Cl. 32*a*. 20; *Chem. Abs.*, **31**, 6434 (1937).

Sealing metal to glass. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 475,688, Dec. 8, 1937 (Oct. 11, 1935).

Borosilicate glass. JENAER GLASWERK SCHOTT & GEN. Fr. 808,619, Feb. 11, 1937; *Chem. Abs.*, **31**, 6433 (1937).—Be oxide or primary materials containing Be oxide are added to borosilicate glass to increase the resistance thereof to alkaline liquids. Thus a glass may contain SiO_2 70.5, K_2O 5, BeO 7, B_2O_3 15, and Al_2O_3 2.5% or SiO_2 49, Na_2O 10, BaO 25, BeO 5, B_2O_3 5, Al_2O_3 5, and TiO_2 1%.

Building block. C. E. JOHNSON (Libbey-Owens-Ford Glass Co.). U. S. 2,101,181, Dec. 7, 1937 (Oct. 2, 1936). A building block of the character described comprises a body portion formed from plastic material, a face plate of vitreous material covering a surface of the body portion and provided with grooves in opposite edges thereof, and a metal frame arranged entirely around the body portion and having portions thereof received within the grooves in the edges of the face plate.

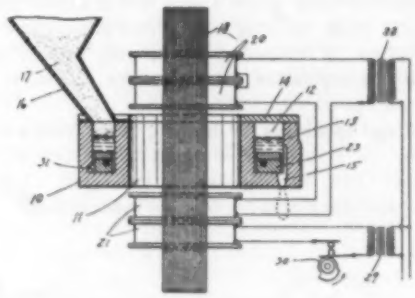
Bulb for luminous discharge lamps. CORNING GLASS WORKS. Fr. 808,048, Jan. 27, 1937; *Chem. Abs.*, **31**, 6434 (1937).—The bulb is composed of a fluorescent opal glass having a maximum Fe content of 0.02% of Fe_2O_3, obtained by fusing a mixture containing fluorspar and a compound of F such as cryolite, Na_2SiF_6, K_2SiF_6, and AlF_3, the fluorspar and the F being used in the ratio comprised between 1:1 and 3:1 so that the opalescence is rendered stable.

Clear-vision antiglare windshield. WILLIAM BENNETT. U. S. 2,102,454, Dec. 14, 1937 (June 25, 1937). A clear-vision windshield for automobiles, etc., comprises a fixed flat transparent sheet of safety glass, a transparent concave tinted member spaced from and aligned with the glass, tracks curved to correspond to the arc formed by the concave member and wherein the member is adapted to be slid out of alignment with the glass, air-heating means, means for conducting and delivering heated air to the space between the glass and transparent member, and means for releasing the transparent member from the tracks.

Construction of optical lenses and mirrors. W. E. WILLIAMS. Brit. 475,035, Nov. 24, 1937 (May 7, 1936).

Cooling furnace for glassware. VEREINIGTE LAUSITZER GLASWERKE A.-G. (Bruno Kindt, inventor). Ger. 645,571, May 31, 1937; Cl. 32*a*. 28; *Chem. Abs.*, **31**, 6434 (1937).

Electric furnace. JOHN FERGUSON (Fairmount Glass Works, Inc.). U. S. 2,101,675, Dec. 7, 1937 (May 17, 1935). An induction furnace includes a hearth adapted to contain a charge of material, a primary winding supplied with alternating current, and a secondary conductor in



heat-exchange relation with the material on the hearth and inductively linked with the primary winding, the secondary conductor being in the form of a ring of relatively refractory resistance material having a core of less refractory conducting material of lower specific resistance.

Furnace construction. C. H. WISE (Hartford-Empire Co.). U. S. 2,101,786, Dec. 7, 1937 (Jan. 25, 1936). A furnace structure comprises a pair of opposing buckstays, a tie rod therebetween, means providing a resilient connection between the tie rod and at least one of the buckstays, and optionally usable means providing a rigid connection therebetween, all the means being so constructed and arranged as to afford undiminished support to the furnace structure during the transition from the resilient to the rigid connection and vice versa.

Furnace for manufacturing tubes of glass or analogous material. M. DESCARSIN. Brit. 475,014, Nov. 24, 1937 (Feb. 20, 1936).

Fusing together of glass and ceramic bodies. STEATIT-MAGNESIA AKT.-GES. Brit. 475,575, Dec. 8, 1937 (Feb. 20, 1935).

Glassblowing machine. LYNCH CORP. Ger. 642,786,

March 19, 1937; Cl. 32*a*. 12; *Chem. Abs.*, **31**, 6434 (1937).

Glass building units. Corning Glass Works. Brit. 474,725, Nov. 17, 1937 (March 25, 1936).

Glass doorknob. A. B. Redman (T. C. Wheaton Co.). U. S. 2,100,818, Nov. 30, 1937 (Feb. 16, 1937).

Glass masonry. J. M. Guthrie (J. C. Keaney). U. S. 2,102,149, Dec. 14, 1937 (April 22, 1937).

Glass-to-metal seals. Standard Telephones & Cables, Ltd. Brit. 474,706, Nov. 17, 1937 (Feb. 4, 1936).

Glass sheet supporting means. S. K. Kotowski (Libbey-Owens-Ford Glass Co.). U. S. 2,100,512, Nov. 30, 1937 (Sept. 6, 1935).

Heat-absorbing glasses. Jenaer Glaswerk Schott & Gen. Brit. 475,336, Dec. 1, 1937 (July 13, 1936).

Laminated glass. J. S. Tinsley (Hercules Powder Co.). U. S. 2,099,086, Nov. 16, 1937 (Sept. 17, 1934).

Luminescent glass. Hellmuth Fischer. U. S. 2,099,602, Nov. 16, 1937 (Feb. 21, 1936).

Machine for producing glass vessels from tubing. Jakob Dichter. U. S. 2,101,213, Dec. 7, 1937 (Feb. 16, 1933).

Making glass tubes. Felix Meyer. Ger. 644,251, April 27, 1937; Cl. 32*a*. 27; *Chem. Abs.*, **31**, 6434 (1937).

Making glass tubes to exact internal form. F. Meyer. Ger. 642,907, March 4, 1937 (June 8, 1935); M 131,234, VI/32*a*. Gp. 27; *Jour. Soc. Glass Tech.*, **21** [86] A266 (1937).—A glass tube supported in a vertical position from above is rotated above a plug and is heated over its whole length while the plug is traversed along the bore.

Manufacture of laminated glass, etc., and of sheets suitable for incorporation. A. Kampfer. Brit. 474,076, Nov. 10, 1937 (Feb. 18, 1936).

Method and apparatus for drawing fibers from a viscous substance. N. V. Mij. tot Beheer en Exploitatie van Octrooien. Brit. 475,384, Dec. 1, 1937 (Jan. 15, 1936).

Method and apparatus for feeding molten glass. F. L. O. Wadsworth (Ball Bros. Co.). U. S. 2,099,088, Nov. 16, 1937 (June 25, 1934; renewed Jan. 14, 1937).

Method and apparatus for making double-walled glass vessels. Jakob Dichter. U. S. 2,102,357, Dec. 14, 1937 (April 20, 1934). In the manufacture of double-walled, substantially bottle-shaped, glass vessels in one piece, the step of forming the neck by exerting centrally directed pneumatic pressure on the neck portion of the inner wall.

Production of glass tubing with multilayer walls. Glaswerk G. Fischer. Ger. 642,488, Feb. 18, 1937 (Feb. 20, 1936); G 92,238, VI/32*a*, Gp. 24_{03}; *Jour. Soc. Glass Tech.*, **21** [86] A266 (1937).—A "post" of glass prepared in the usual way is inserted within one or more rings of glass of a different kind and then drawn out, the material of the ring(s) forming a surface layer on the tube.

Refractor. T. W. Rolph (Holophane Co., Inc.). U. S. 2,099,034, Nov. 16, 1937 (April 25, 1935).

Safety glass. Pittsburgh Plate Glass Co. Brit. 474,268, Nov. 10, 1937 (Feb. 25, 1936).

Safety glass. Chemische Forschungsgesellschaft m.b.H. (Willy O. Herrmann and Erich Baum, inventors). Ger. 644,828, May 14, 1937; Cl. 39*a*. 17.50; *Chem. Abs.*, **31**, 6434 (1937).—Use is made of glass plates and one or more intermediate layers treated with a nonsplintering layer such as paper, gelatin, size, etc.

Vacuum-tight seals for current leads into quartz or refractory-glass vessels. Quarzlampen, Ges. Brit. 474,867, Nov. 24, 1937 (Dec. 27, 1935).

Vitreous compositions or glasses. H. G. Grimm and Paul Huppert (I. G. Farbenindustrie A.-G.). U. S. 2,100,391, Nov. 30, 1937 (Aug. 12, 1936). A clear vitreous composition is obtained by fusion which comprises an oxidic component and a vitrifying component containing between 10 and 100% by weight of Al_2O_3 and P_2O_5, Al_2O_3 being present in a proportion which, reckoned on P_2O_5, is larger than that present in $AlPO_4$ but does not exceed about 4 parts by weight per each part of P_2O_5.

Structural Clay Products

Formation of cracks in dry-pressed brick. S. P. Loginov. *Ogneupory*, **3**, 203–206 (1935); *Chem. Abs.*, **29**, 6006 (1935).—Theoretical and practical considerations based on the study of the work of different kinds of presses are given.

Rehydration of fired brick clays. L. R. Barrett. *Trans. Ceram. Soc.*, **36** [4] 201–16 (1937); see *Ceram. Abs.*, **16** [5] 162 (1937). R.A.H.

PATENTS

Building construction. D. D. Whitacre. U. S. 2,102,447, Dec. 14, 1937 (April 1, 1935). In a load-bearing structure the combination of a plurality of blocks adapted to sustain load in compression having load-bearing engagement with each other through substantially planar surfaces presented by adjacent blocks in load-bearing contact, and longitudinally disposed tension means extending transversely of the contacting surfaces and secured to blocks longitudinally spaced in the structure, positioned in the region of tension of the structure, and holding adjacent blocks in load-bearing contact on the contacting surfaces.

Dry masonry. Erich Honigmann and Friedrich Bruckmayer (N. H. Moos and Heinrich Eisler). U. S. 2,100,958, Nov. 30, 1937 (April 5, 1937). Intermediate joint material for use between courses of brick or stones in a dry masonry structure comprises a sheet of material having, at least in superficial portions thereof, a limited degree of compressibility under load in order to compensate for surface inequalities of the brick or stones mainly composing the masonry, the material having also great tensile strength so as to impart to the masonry a high resistance to buckling, bending, and distortion, and comprising at least one of the materials of the class consisting of asbestos, cellulose derivatives, protoplasm, seaweed, moss, and paper impregnated with a moisture-repellent substance, and mixtures including light concrete, superficially compressible cement, dolomite, siliceous earth, and pumice, and the sheet of material having a reinforced construction.

Machine for surface treatment of brick, etc., in the plastic state. H. Sutcliffe and G. Hearth. Brit. 474,631, Nov. 17, 1937 (May 16, 1936).

Refractories

Action of alkalis on refractory materials: II, Action of potassium chloride vapor on refractory materials at 1000°C. F. H. Clews, A. Green, and A. T. Green. *Trans. Ceram. Soc.*, **36** [4] 217–24 (1937); see *Ceram. Abs.*, **14** [11] 278 (1935). **III, Volatilization from alkali-impregnated refractory materials at 1000° and 1100°C.** *Trans. Ceram. Soc.*, **36** [4] 225–32 (1937).—Data are given to show that the rate of volatilization of alkali at 1100°C from potash-impregnated silica and fireclay materials is much more rapid from the former than from the latter. There is approximately a fourfold decrease in the rate of volatilization at 1100°C compared with 1000°C, despite the increase in vapor pressure that might be expected at the higher temperature. The volatilization of soda at 1000°C from impregnated refractory materials is similar to that of potash though at a reduced rate. R.A.H.

Action of alkalis on refractory materials: VIII, Aspects of the action of alkali chloride vapor on refractory materials at 1000°C. F. H. Clews, H. M. Richardson, and A. T. Green. *Refrac. Materials Joint Comm., Inst. Gas Engrs., 28th Rept.*, pp. 32–38 (1937).—Both low-fired and high-fired samples of fire brick showed marked increase in weight and size after prolonged exposure to the vapor of sodium chloride at 1000°C. The effect was similar to that produced by potassium chloride, reported in Part V (*Ceram. Abs.*, **16** [5] 150 (1937)). The low-fired brick showed greater expansion. Tests made on sillimanite materials show results comparable to those produced on fire brick. Alternate heating and cooling of the specimens appeared to influence the expansion more than long periods of exposure to the vapor. Transverse tests on fire brick and silica showed decreased strength accompanying the observed expansions. No explanation as to the cause of the expansion is attempted. **IX, Experiments on the action of the vapor from sodium aluminate and sodium carbonate at various temperatures.** *Refrac. Materials Joint Comm., Inst. Gas Engrs., 28th Rept.*, pp. 38–44 (1937).—The action of the vapor from two sodium aluminates on clay and silica refractories at temperatures ranging from 900° to 1200°C is described. At all temperatures in this range, the more aluminous materials showed less increase in weight than the fire clay; these showed less than the siliceous and silica refractories. On the other hand, with sodium carbonate as the source of alkali vapor, silica materials showed smaller increases in weight than the fireclay products. R.F.Rea

Action of slags on refractory materials: I, Application of tests to the study of the action of CaO–Al_2O_3–SiO_2 slags on refractory materials. W. Hugill and A. T. Green. *Refrac. Materials Joint Comm., Inst. Gas Engrs., 28th Rept.*, pp. 44–60 (1937).—The aim of this investigation is to give a better understanding of the fundamentals of slag action. Three contrasting methods of testing were correlated, and microscopic examinations were made on the specimens after testing; in method 1, the refractoriness of a range of mixtures of slag and brick was measured; in method 2, the extent of corrosion and penetration was measured on a standard cylinder of compressed slag melted under specified conditions on the upper surface of the test brick; in method 3, the extent of erosion, obtained by injecting powdered slag into a blast flame impinging on the test brick under standard conditions, was measured. Fourteen specimens of refractories, including nine fireclay, four silica, and one sillimanite, were used. The CaO content of the four slags varied between 37 and 57%. Data obtained by the first method have been correlated with the lime-alumina-silica diagram. A marked feature is the relatively low minimum softening temperature, ranging only from 1140° to 1200°C, despite a wide variation in the brick composition. In method 2, interaction involving liquefaction occurred between the slag and brick at about minimum melting temperature as disclosed in method 1. Microscopic examination of the samples showed that, in most cases, anorthite crystals were formed by the action of the liquid on the brick, the residual melt penetrating farther into the brick. This liquid is conducive to the formation of mullite in all but the highly siliceous materials. Silica brick showed marked penetration, and in these no anorthite crystallized. It is apparent that the extent of corrosion and penetration increases with increasing lime content of the slag, and indications of an order of merit in the fireclay and aluminous brick have been obtained from the measurements of the depth of corrosion and penetration. The results obtained from the slag-erosion test are the least amenable to numerical measurement, and a classification can be made only on general appearance of the specimens. R.F.Rea

Alumina from bauxite. R. Seiden. *Chem. Trade Jour.*, **99**, 144 (Aug. 21, 1936); *Metals & Alloys*, **8** [3] MA133 (1937).—S. describes the Müller-Hiller modification of the Bayer process. The principal change is the substitution of a continuous pressure plant for decomposition of the bauxite with alkali for the intermittent Bayer decomposition in high-capacity autoclaves. With the exception of the decomposition plant, all of the equipment used in the ordinary Bayer process can be used. There is a saving of more than 50% in heat requirements and more than $4 per ton of calcined Al_2O_3. The modified method can be applied satisfactorily to varieties of bauxite unsatisfactory for standard Bayer methods.

Bonding agents for refractories. Anon. *Chem. Industries*, **39**, 145–47 (Aug., 1936); *Metals & Alloys*, **8** [6] MA356 (1937).—Possible applications of ethyl-silicate solutions are described. Partially hydrolyzed silicic-acid ester is suggested as an excellent bonding material for a variety of ceramic ware; the very sticky colloidal silicic acid deposited by hydrolysis dries to hard, vitreous-like silica. Price considerations exclude its use in making ordinary refractory brick, but some special refractory applications are suggested.

Brick of artificial agglomerated mullite for regenerator packing. P. Bergeron. *Jour. Soc. Glass Tech.*, **20**, 586–94 (1936); see *Ceram. Abs.*, **16** [3] 90 (1937). C.J.P.

Cast sillimanite glass pots. R. Moretti. *Ind. Vetro & Ceram.*, **8** [12] 440–52 (1935).—The properties of minerals of the sillimanite group and their use as refractory material are described. M. tested different mixes of clay and sillimanite for slip cast pots; physicochemical and mechanical characteristics were investigated. M. con-

cludes that fired sillimanite, used instead of clay, increases refractoriness and resistance to molten glass; drying time is shortened. The best clay-sillimanite ratio is 20:80, the suitable clay-grog ratio being 40:60. The results are tabulated. Literature references. F.E.V.

Chromite and chrome-magnesite refractory materials. P. S. MAMYKIN. *Uralskaya Metallurgiya*, **1936**, No. 1, pp. 42–47.—The production of chromite and chrome-magnesite refractory ware is equal to about 15 to 20% of the production of magnesite refractories. As a consequence of the rise of working temperatures of various technical processes, the consumption of chromite refractories will be increased because of their high melting point (> 1900°) and because they are unaffected by slags of any composition. M. describes various patents on the manufacture of refractory brick from chrome ore, etc. The purpose of this study is to establish the properties of chrome-magnesite refractories, with Ural chromite and magnesite as a base and without any additions except water. The magnesite and chromite used were of the following composition:

	Moisture	SiO_2	Al_2O_3	Fe_2O_3	MgO	Cr_2O_3	CaO
Magnesite	0.15	2.22	1.81	2.20	93.34		
Chromite	0.22	6.97	18.55	20.90	17.12	32.33	0.98

M. gives the production process and the properties of the brick. B.E.K.

Clay-bonded silica refractories in segmental horizontal retorts. A. EDWARDS. *Refrac. Materials Joint Comm., Inst. Gas Engrs., 28th Rept.*, pp. 80–82 (1937).—Retorts built with a clay-bonded siliceous material (91% SiO_2, 6% Al_2O_3) are compared with retorts constructed of lime-bonded silica. The clay-bonded retorts were found to be freer from leakage, and they did not develop the erosion of the floor segments between 4 and 7 feet from the mouthpiece typical of the lime-bonded silica retorts. The greater gas-tightness was caused by the glazing of the inside and outside of the retort surfaces with a brown slag. This slag eventually caused trouble by running down and blocking the producer gas nostrils. Modification of design and the use of different materials for different parts of the setting are suggested as means by which this latter disadvantage may be overcome. R.F.REA

Combined alkaline method for obtaining alumina. V. A. MAZEL. *Legkie Metally*, **4** [2] 22–31 (1935); abstracted in *Chem. Zentr.*, **1935, ii,** 1591.—A combined alkaline method is suggested for obtaining Al_2O_3 from Ural bauxites: (1) a wet decomposition, (2) a dry decomposition of red mud obtained from the first treatment, and (3) a joint working of the first and second slips. The advantages claimed are (*a*) an increased Al_2O_3 yield and (*b*) smaller losses of Na_2O. M.V.C.

Conditions for heating grog products when determining additional shrinkage. D. N. POLUBOYARINOV AND O. M. GRACHEVA. *Ogneupory*, **4**, 692–701 (1936); abstracted in *Chem. Zentr.*, **1937, i,** 4675.—With increasing temperature and heating time, the additional shrinkage of grog products increases. Wet-shaped products, when fired to 1350°C, show a change in volume as specified, while with semidried and pressed products this has not been obtained. An increase in additional shrinkage occurs with increased Fe content of the product and when it is fired in reducing atmosphere. With rapid heating, shrinkage decreases. The absolute values of shrinkage decrease with the increase in the size of the product and increased fineness of grains. M.V.C.

Crystal structure of Mg-Al spinels with an Al_2O_3 surplus and γ Al_2O_3. G. HÄGG AND G. SÖDERHOLM. *Z. Physik. Chem.*, **B29**, 88–94 (1935); abstracted in *Chem. Zentr.*, **1935, ii,** 1133.—The system MgO–Al_2O_3 was studied by means of X-rays with Cr-K radiation. M.V.C.

Determination of mechanical properties of refractories at high temperatures. B. YA. PINES AND E. I. TER-MIKAEL'YANTS. *Ogneupory*, **4**, 181–87 (1936); *Chem. Abs.*, **30**, 6908 (1936).—A specially constructed device permits determinations up to 1700°. A SiC-C thermocouple was used for temperature measurements. With small cubes (1 cm.), even of nonhomogeneous materials (SiO_2), reliable data were obtained. Based on work done with $MgCO_3$, SiO_2, dunite, SiC, etc., it was found that softening under load corresponds not to the beginning of softening, but to an advanced stage of "flow" of the material.

Determination of refractoriness. D. S. CHOKOLOV. *Ogneupory*, **4**, 94–96 (1936); *Chem. Abs.*, **30**, 6908 (1936).—A continuous cryptol furnace used for firing insulators for spark plugs may be employed, in which the samples are moved inside a vertical tube from below to the top. This method takes about one-third the usual time.

Determining porosity of refractory materials. A. I. SHARPSHTEIN AND E. I. KHEIFETZ. *Ogneupory*, **2** [10] 24–27 (1934); *Zavodskaya Lab.*, **3**, 732–35 (1934); *Chem. Abs.*, **29**, 5239 (1935).—The dried sample is heated for 20 to 30 min. at 110 to 115° and then boiled for 30 to 40 min. in H_2O, cooled, wiped with a moist towel, and weighed. The Sager volumometer is not sufficiently accurate. A simple device, based on the hydrostatic law of Archimedes, gives accurate results. It consists of a balance, one scale of which is immersed in water. The sample is put on this scale and weighed with an accuracy of 0.01 g. The volume in cc. is $V = P_1 - P_2 + K$, in which $P_1 - P_2$ is the loss of weight in water and K is a correction coefficient dependent upon the temperature of the water.

Development of convection heating equipment. ANON. *Ind. Heating*, **2** [10] 601–602; [11] 669–70; [12] 711 (1935); *Metals & Alloys*, **7** [3] MA122 (1936).—The developments in this field are reviewed, and furnaces and their equipment, with particular consideration of metallurgical operations, are described with many practical examples.

Disintegration of bauxite by sodium sulfate. C. SLONIM. *Chem. Listy*, **29**, 60–63 (1935); abstracted in *Chem. Zentr.*, **1935, ii,** 2034.—The disintegration of Al_2O_3 (pure or as bauxite) with Na_2SO_4 was studied in the presence of steam at temperatures varying between 950° and 1200° under different conditions. M.V.C.

Economic importance of blast-furnace fusion of Ural ferruginous bauxites. V. J. DOVGOPOL. *Uralskaya Metallurgiya*, **1936**, No. 5, pp. 31–37.—The average composition of the Ural bauxites (Krasnaya Shapochka) is Al_2O_3 50 to 48, Fe_2O_3 20 to 28, SiO_2 2 to 5, and TiO_2 2.5 to 4%. The blast-furnace fusion of bauxites makes possible the production of aluminous cement and aluminous-slag cement in the U.S.S.R. D. cites multiple instances

of the use of this cement for industrial purposes. The production process of blast-furnace high-alumina slag, and the economical considerations of its production are described. D. concludes that the blast-furnace fusion of Ural bauxites gives high-alumina slags for the production of high-grade cement and clean alumina. B.E.K.

Effect of chemical composition of refractories on the separation of carbon according to the reaction $2CO \rightleftarrows CO_2 + C$. R. N. Golovatnyi. *Ogneupory*, **4**, 686–91 (1936); abstracted in *Chem. Zentr.*, **1937, ii**, 2053.—In the reaction $2CO \rightleftarrows CO_2 + C$, FeO is the most active catalyzer at 500°, while at 800° to 1000°, it is the metallic Fe. This reaction also takes place in refractories, even in the absence of Fe oxides. By lowering the alumina content of refractories and increasing their silica content, the decomposition of CO is reduced; the same is true with the addition of $CuSO_4$, water-glass, or 5% Cr_2O_3 to grog mixes; the addition of 6 to 15% MgO, however, has an opposite effect. Semiacid refractories are more suitable for the manufacture of linings resistant to CO, *e.g.*, blast furnaces. M.V.C.

Effect of hydrocarbon gases on refractory materials: IV, Effect of ethylene on refractory materials. E. Rowden. *Refrac. Materials Joint Comm., Inst. Gas Engrs., 28th Rept.*, pp. 11–13 (1937).—Because methane, a saturated hydrocarbon gas, causes the disintegration of fire brick under certain conditions, it was thought possible that an unsaturated hydrocarbon, such as ethylene (C_2H_4), might attack the fire brick more quickly and at a lower temperature. Fire brick and silica brick were unaffected, except for a gray discoloration when exposed to an atmosphere of ethylene at 600° and 800°C for more than five days. The gas polymerized and condensed, forming tar and other liquid and solid hydrocarbons, the higher temperature producing a larger amount of these heavier hydrocarbons. **V, Effect of coal gas on refractory materials.** *Ibid.*, pp. 13–21.—In studying the effect of coal gas on fire brick at elevated temperatures, dry CO_2-free coal gas produced disintegration, whereas dry coal gas containing 3 to 4% carbon dioxide had no effect on the specimens other than to produce a gray discoloration. Disintegration was caused by the growth of carbon spots in the specimens. A tentative explanation of the inhibiting action of the carbon dioxide is based on the reaction of carbon dioxide with carbon to form carbon monoxide. At 850°C the reaction $C + CO_2 \rightarrow 2CO$ proceeds at a greater rate than the reverse reaction $2CO \rightarrow C + CO_2$. Disintegration occurred only at a temperature of 800° or above. Moist coal gas had no effect at 900°C. For Parts II-III see *Ceram. Abs.*, **16** [5] 150–51 (1937). R.F.Rea

Hand and machine shaping of grog brick. R. Klesper. *Sprechsaal*, **70** [24] 309–11; [25] 323–26; [26] 337–38; [27] 351–53; [28] 363–65; [29] 372–74 (1937).—A comparative study is presented of methods used in shaping grog brick and their advantages and disadvantages, with a brief description of equipment employed. M.V.C.

Heat conductivity of refractory materials. H. Cassan. *Jour. Usines Gaz.*, **61** [12] 281–91; [14] 387–93 (1937).—C. summarizes the results of three years of experiments on calorific conductivity determinations. R.W.D.

High-alumina masses. Ya. V. Klyucharov and S. A. Levenshtein. *Ogneupory*, **4**, 84–91, 188–96, 252–60 (1936); *Chem. Abs.*, **30**, 6907 (1936).—Tests were made with artificial Al_2O_3, andalusite, and kyanite, with different grog and binding materials. See *Ceram. Abs.*, **17** [1] 19 (1938).

High porosity sillimanite brick: III. F. H. Clews and A. T. Green. *Refrac. Materials Joint Comm., Inst. Gas Engrs., 28th Rept.*, pp. 71–76 (1937).—The properties of some sillimanite products of high porosity prepared in the laboratory were investigated. The porosity was increased (1) by introducing various proportions of fine anthracite into the mix and burning it away when the product was fired and (2) by introducing various proportions of aluminum powder and hydrochloric acid into the plastic material, which was thus bloated before firing. Brick made by method 1, containing 35% anthracite and 7% bentonite, had a porosity of about 70% and showed only slight subsidence under a light load at 1350°C. The following mix was most successful for small-scale trials by method 2: 400 g. of −80-mesh sillimanite and 200 g. china clay were mixed into a slip with 180 cc. water containing 0.6 g. sodium carbonate; 30 to 50 g. of very fine aluminum powder were added and thoroughly distributed; 50 cc. dilute (1:1) hydrochloric acid were then added and mixed for two minutes before pouring into molds. For Part II see *Ceram. Abs.*, **15** [10] 302 (1936). R.F.Rea

High-quality (Corhart) tank blocks. K. Knuth. *Glastech. Ber.*, **13**, 116 (1935); *Trans. Ceram. Soc.*, **34**, 85A (1935).—The manufacture of Corhart blocks on a large scale was started in America in 1926, and a subsidiary company began operations in Modane, France, in 1929. A highly aluminous mixture of raw materials is fused in an electric furnace at about 2200°, and the molten mass is cast in sand molds. The chemical composition corresponds with mullite, the alumina content being about 71%. The physical properties of Corhart material are outlined briefly, and details are given regarding its use and service in European glassworks. In all cases, much greater durability and better quality glass were reported by the works visited.

High-temperature ceramics. H. v. Wartenberg. *Abt. Ges. Wiss. Göttingen, Math.-Physik. Klasse*, [3]., No. 18, pp. 106–108 (1937); abstracted in *Chem.* [3]., **1937, ii**, 2730.—The chief difficulty in the technical manufacture of materials melting at temperatures of 1800° C and higher lies in the nature of suitable furnace refractories which will not react with the material to be melted. Because a limit of serviceability has been reached with silicates, pure highly refractory oxides, such as magnesite, are being used more extensively. The principles for a rational use of these materials were first developed by W. and his collaborators by determining the melting diagrams of mixtures of such oxides; at the present time, phenomena of crystallization and surface tensions of melts are being studied. M.V.C.

Influence of molten aluminum on firebrick lining in an electric furnace. A. N. Lysenko. *Legkie Metally*, **4** [5] 8–13 (1935); *Chem. Abs.*, **30**, 683 (1936).—In remelting Al in an electric resistance furnace with a firebrick lining, the Al penetrated into the porous brick, reduced the SiO_2 and Fe_2O_3, and made the brick a conductor of electricity. The slagging of the walls progressed upward from the level of

the metal to the top of the furnace where it short-circuited the Ni-Cr resistor units.

Influence of nozzle refractories on teeming speeds of ingots. A. JACKSON. *Metallurgia*, **12**, 158–60 (1935); *Chem. Abs.*, **29**, 7894 (1935).—Data are given to show how the rate of pour varies with the nozzle refractory and the number of tons of steel poured. Nozzles are made of clay and (or) magnesite.

Insulating refractories, their manufacture and physical properties. G. A. BOLE. *Trans. Amer. Foundrymen's Assn.*, **8** [5] 261–73 (1937). H.E.S.

Insulation against heat losses. ANON. *Fuel Economist*, **10**, 680–82 (Jan., 1935); *Jour. Iron & Steel Inst.* [London], **131** [1] 327 (1935).—The properties of some modern heat-insulating materials and their application are discussed.

Investigations on the effect of the addition of *ciment fondu* to various refractory materials, including fire clay, chrome, magnesite, chrome-magnesite mixtures, etc. A. A. CHADEYRON AND W. J. REES. *Refrac. Materials Joint Comm., Inst. Gas Engrs., 28th Rept.*, pp. 76–77 (1937). —Fused aluminous cement (*ciment fondu*), when added to various refractory materials, conferred considerable strength in a very short time, the strength being proportional to the amount of cement present. Refractoriness-under-load tests showed the best results with basic materials such as chrome and magnesite. While the cement seriously lowers the refractoriness of fireclay grog, it is recommended for monolithic work and special shapes where the temperature does not exceed 1200°C. *Ciment fondu* is also suggested as a bonding agent in refractory cements. Thermal-expansion measurements indicated that the addition of the cement tends to give a slight increase in thermal expansion up to 1050°C. R.F.REA

Kaolin and refractory earths of Larnage-Doueras. V. CHARRIN. *Céram., Verrerie, Email.*, **3**, 421–22 (1935); *Chem. Abs.*, **30**, 2339 (1936).

Magnesite brick resistant to spalling. Z. YA. TABAKOV, V. V. BELOVODSKIĬ, AND G. TAZITDINOV. *Ogneupory*, **4**, 102–12 (1936); *Chem. Abs.*, **30**, 6906 (1936).—Magnesite brick proved superior in a 150-ton open-hearth furnace.

Manufacture and uses of silica refractories. T. McC. FIRKIN. *Jour. Australian Chem. Inst.*, **4** [3] 105–14 (1937).—Silica refractories are often specified as those which contain more than 92% SiO_2, but this definition admits semisilica ware and silica bonded with clay. True silica refractories are made from high-grade quartzite bonded with a small percentage of lime. At the Waratah (N.S.W.) works of the Newbold Silica Firebrick Co., the quartzite used is 97% SiO_2, and the structure is of fine, close angular grains of silica cemented with an interstitial silica cement. The stone must be hard so that, on crushing, a splintered product is obtained; maximum expansion and minimum specific gravity should be attained during the first firing to 1450°C for 5 hours. At the quarries, the stone is broken to 2-inch size, and it is given further reduction at the works. Sufficient rock flour is produced to interact with the added flux (2 to 2½% CaO) during firing. Hand molding is practiced, but Harbison-Walker drop-molding machines are being installed. After being run through tunnel driers, the ware is set in periodic downdraft kilns and fired to 1500°C (cone 18) in 15 days, held there 2 days, and cooled for 16 days. The stability of the silica inversions is discussed. The physical properties of a type of silica brick are as follows: refractoriness, 1730°C; refractoriness under load of 25 lb./sq. in., 1690–1710°; refractoriness under load of 50 lb., 1670°–1690°C; no after-expansion at 1450°C; true specific gravity, 2.32; apparent specific gravity, 1.75; true porosity, 25%; cold crushing strength, 6470 lb./sq. in.; and linear thermal expansion from 15° to 1400°C, 1.2 to 1.3%. See *Ceram. Abs.*, **16** [1] 23 (1937). H.H.S.

Materials with high alumina content. Technological properties. YA. V. KLYUCHAROV. *Ogneupory*, **4** [12] 783–91 (1936); abstracted in *Chimie & Industrie*, **38** [3] 512 (1937).—Aluminous materials vary little in humidity, except those which are plastic and have a high water content. Apparent porosity and water absorption, however, vary greatly. Products of low porosity are those obtained from ordinary andalusite containing quartz and mica. Porosity and true porosity may be increased by grog additions from andalusite or alumina. Prefiring of raw andalusite greatly increases the number of open pores. Aluminous materials may be classified in order of increasing mechanical resistance as follows: materials containing (1) a pure andalusite base, (2) a corundum and andalusite base, (3) kyanite, alite, and alumina, and (4) a raw andalusite base. The latter show the lowest thermal resistance. M.V.C.

Methods to increase high temperatures. EUGEN RISHKEVICH. *Wärme*, **60**, 467–71 (1937); abstracted in *Chem. Zentr.*, **1937**, ii, 2052.—New ceramic materials produced from sintered oxides and which may be used at high temperatures are discussed in detail. The properties of sintered alumina, spinel, and magnesia are analyzed. A new furnace operating on the principles of surface combustion for temperatures of 2000°C and heated by illuminating gas and air is described. M.V.C.

Microstructure and technological properties of magnesite brick from Satkinskiĭ and Khalilovskiĭ deposits. N. S. MANUILOVA. *Ogneupory*, **4** [1] 45–53 (1936).—The microstructure of brick manufactured from Satkinskiĭ and Khalilovskiĭ magnesite differs in respect to structure of periclase grains and the quantity and distribution of the bond. Brick made from the former magnesite are of high quality, while those made from the latter magnesite have low mechanical strength and deform under load at 1430°C. (1) Technological properties of magnesite brick depend to a great extent on the structure of periclase grains and chiefly on a uniform distribution of the silicate intermediate layers between them. (2) Mechanical strength of magnesite brick is related to the formation of forsterite in the bond. (3) Sintering of periclase and differences in its grain size depend on the quantity of fluxes used and their correct distribution in the brick. M.V.C.

Mineralogy of forsterite refractories. V. V. GONCHAROV AND A. T. KLEINBERG. *Ogneupory*, **4**, 205–13 (1936); *Chem. Abs.*, **30**, 6908 (1936).—To obtain highly refractory mixtures from talc-magnesite minerals, the correct amount of $MgCO_3$ must be added to form a forsterite periclase or forsterite composition. Practically, the latter is more easily obtained. The composition results from the interreaction of $MgCO_3$ and talc, the latter retaining its constant phase composition from the moment

of complete dehydration to the higher firing temperatures. Differences in mineralogical composition of the products obtained result from variations in preparation and heat treatment. Quantitatively, the reaction is sufficiently complete at 1450 to 1500°, which temperature is recommended for firing. Larger crystals of forsterite and a denser mass result from a longer time at the final firing temperature. The rate of cooling does not influence the composition and microstructure. Higher pressure during forming results in a denser mass richer in forsterite. The same result is obtained by a preliminary firing of talc. Increasing the firing temperature to 1600 to 1700° increases the completeness of the reaction. The presence of Fe_2O_3 leads to the formation of magnesioferrite, which impedes the reaction.

Modulus of elasticity of magnesite refractories: I, Importance of the modulus of elasticity of refractories and apparatus for its measurement. S. KONDO AND H. YOSHIDA. *Jour. Japan. Ceram. Assn.*, **44,** 611 (1936); *Trans. Ceram. Soc.*, **36** [3] 24A (1937).—The effect of differences in raw materials and manufacturing methods on the modulus of elasticity and the relation between the modulus of elasticity and spalling tendency were studied. Apparatus for the accurate measure of the modulus of elasticity is described. **IV, Modulus of elasticity at high temperatures.** S. KONDO AND H. YOSHIDA. *Jour. Japan. Ceram. Assn.*, **44,** 866 (1936); *Trans. Ceram. Soc.*, **36** [3] 24A (1937).—The relation between modulus of elasticity and temperature was studied. Specimens were placed between knife-edges, and a load was applied which caused a definite deflection at 25°. Tests were carried out on three Japanese brick, a Veitsch brick, and a Radex brick. The deflection of the Radex brick, which was greatest at 50°, decreased irregularly and gradually with rising temperature, while that of the other brick increased markedly between 125° and 450°, 300° and 475°, 350° and 450°, and 250° and 425°, respectively; it was noticeably higher at 450° than at 25° and showed a peak at 625° or 600°. The Radex indicated a small peak at 400°. The slight but rapid rise in the deflection at about 600° is difficult to explain. The decrease in deflection beginning at 400° to 825° may be due to the formation of a glassy phase. The moduli of elasticity at high temperatures were proportional to those at room temperature.

Natural and artificial zeolites. J. H. FRYDLENDER. *Rev. Prod. Chim.*, **40** [7] 193–97; [8] 226–30 (1937).—General considerations and manufacturing processes from alumina and natural silicates and from soluble silicates and aluminous compounds are discussed. As industrial uses of zeolites, F. considers water softening (principles, procedure, and activation of saturated zeolites), preparation of mineral salts, and catalytic properties. R.W.D.

Obtaining corundum in a shaft furnace through aluminium sulfide. A. S. MIKULINSKIĬ. *Zhur. Khim. Prom.*, **14,** 126–30 (1937).—The Haglund process (from aluminous raw materials, pyrite, and carbon) is possible in a blast furnace with ordinary blast or blast enriched with oxygen. The SO_2 formed in the lower part of the furnace reacts with the sulfur carbon compounds, decomposing them; an elementary sulfur is formed. The latter process is catalyzed by the bauxite of the charge. The advantages of this method are as follows: (1) no electrical energy is needed, (2) the productivity of the furnace increases considerably, (3) furnaces of low productivity ineffective for metallurgical purposes can be used, (4) by-products such as pig iron with a high sulfur content, H_2S, and elementary sulfur can be obtained, and (5) with diaspore and bauxite ores and carbonaceous pyrites, corundum can be obtained. P.B. & E.S.

Olivine (dunite) refractory materials. I. L. MOVSCHEVICH. *Novosti Tekhniki*, **12,** 7–8 (1936).—The Ukrainian Research Institute of Refractory and Acid-Resisting Materials has studied the possibility of the preparation of olivine (dunite) refractories with Ural dunite (Nishny Tagil layer) as a base. The specimens studied were of the following composition: SiO_2 34, TiO_2 0.06, MgO 43.28, CO_2 0.36, Al_2O_3 0.1, Cr_2O_3 0.49, CaO 0.10, Fe_2O_3 4.74, FeO 3.15, NiO 0.15, MnO 0.19, Na_2O 0.20, K_2O 0.14, and H_2O 12.46%. The specific gravity of dunite is 2.64 to 2.85, mechanical strength is 760 to 1350 kg./cm.², and refractoriness is about 1815°C. The coefficient of thermal expansion of fired dunite in the interval of 20 to 750° is 1.0×10^{-5}. The method of preparation of olivine refractory materials is described. M. concludes that the optimum temperature of firing of olivine refractory is 1600 to 1620°C. The properties of the olivine refractory prepared by this Research Institute are as follows: settling 0.5 to 4.5% (in dependence on schist composition), volume weight 2.45, apparent porosity 25 to 28%, mechanical strength 160 to 340 kg./cm.², refractoriness about 1835°C, beginning of deformation under load of 2 kg./cm.² 1620 to 1660°, and beginning of destruction 1720° to 1770°. The thermal stability and the resistance of olivine to basic open-hearth furnace slag are higher than those of silica. Because of the high quality of this refractory, it is possible to use olivine refractory instead of silica brick in the roofs of open-hearth furnaces and in electrical furnaces. B.E.K.

Preliminary results of the operation of the Dnieper alumina plant. A. M. FRENKEL. *Legkie Metally*, **4** [1] 4–12 (1935); *Chem. Abs.*, **29,** 4267 (1935).—Low-grade bauxites, after crushing and agglomeration, are fused with coke and limestone in an electric furnace. Fe and Si compounds are reduced to Fe-Si, and Al enters the slag. The slag, containing Al_2O_3 42 to 48, CaO 43 to 49, and SiO_2 5 to 8%, is leached and Al_2O_3 is recovered by precipitation with CO_2. The plant produces 1250 tons of Al_2O_3 monthly with a SiO_2 content of 0.3%. Operation of the electric furnace proved troublesome because of segregation of Ti out of the Fe-Si, causing crusts which had to be periodically removed.

Production of low-silica alumina at the Volkhov alumina plant. M. M. LABODA. *Legkie Metally*, **5** [1] 5–10 (1936); *Chem. Abs.*, **30,** 6681 (1936).—The plant operates on bauxite containing 10 to 15% SiO_2. The aluminate solution, which contains 100 to 120 g. Al_2O_3/liter, is desiliconized by adding 8 to 10 g./liter CaO and heating to 150°. An Al_2O_3:-SiO_2 ratio of 600 to 700 is obtained.

Pyrophyllite as refractory material. G. B. TAUBIN AND B. E. PINDRIK. *Ogneupory*, **4,** 708–13 (1936); abstracted in *Chem. Zentr.*, **1937, i,** 4674–75.—Experiments showed that pyrophyllite had to undergo a special treatment to produce high-grade semiacid refractory materials. Pyrophyllite products containing a 15% addition of refractory clay showed satisfactory physicochemical properties; they

are best suited for iron and steel casting because of their resistance to slag attack. M.V.C.

Quality control of refractory mortars. S. S. KOZAKEVICH. *Zavodskaya Lab.*, **6**, 866–69 (1937).—Mechanical properties of the mortars, tensile and crushing strength, must be determined by the usual methods used for refractories. Fracture tests give inadequate results. The setting from drying is determined by pouring the mortar on a tile. The firmness of binding of the mortar with the brick is determined by binding together two halves of an octagonally shaped sample. The permeability to gases can be determined on cylinders cut in two and bound together by the mortar. Thermal properties are determined as usual. The determination of resistance to slags can be effected on small cubes or cylinders in a cryptol furnace on which powdered slag is poured through a tube. The composition of mortars is controlled by the amount of binding matter, granulometric composition of grog or sand, and moisture content. P.B. & E.S.

Refractories of German serpentine ores. LUISE PIEPER. *Ber. Deut. Keram. Ges.*, **18** [2] 41–64 (1937).—P. discusses the MgO–SiO_2 system and its compounds from a thermochemical standpoint. Various occurrences of serpentine and magnesite in Germany are given geological consideration. Experiments were conducted using Norwegian olivine, three German serpentines, and magnesite found in Zobten, Silesia. Various compositions of these materials were dry pressed in a finely pulverized condition, using 5.8% water and a small amount of dextrine. The test pieces were fired to cones 14 to 15 in saggers, and their firing shrinkage and coefficient of thermal expansion, ratio of free and combined MgO in the fired bodies, color, porosity, and mechanical stability were determined. Petrographic examination of thin sections of some of the bodies are reported. Results of the study showed that it is not necessary to mix powdered serpentine with magnesite and precalcine it to produce a serviceable forsterite brick. Crude serpentine can be ground, and only the fine ground material ground with the requisite amount of magnesite and mineralizer. The finished mix, on being fired, produces a strong reaction on the surface as well as within the serpentine grains. In order to hold the firing shrinkage to a minimum, it is appropriate to use the magnesite as caustic fired magnesite. With a firing temperature of cone 15 a considerable formation of forsterite occurs. Illustrated. E.J.V.

Refractories for power boiler furnaces. MARTIN J. CONWAY. *Nat. Engr.*, **39**, 310–12 (1935); *Chem. Abs.*, **30**, 4285 (1936).

Refractoriness-under-load test: V, Experiments on the behavior of fire brick at high temperatures under increasing load. F. H. CLEWS AND A. T. GREEN. *Refrac. Materials Joint Comm., Inst. Gas Engrs., 28th Rept.*, pp. 61–68 (1937).—Experiments were conducted on fire brick to determine the value of a refractoriness-under-load test in which the temperature was maintained constant and the load gradually increased. Deformation-load-time curves are given for four types of fireclay brick. The information obtained is similar to that given by a constant load-rising temperature test. The rate of load increase is important. The behavior of silica brick under the increasing load test is now under investigation. For Part IV see *Ceram. Abs.*, **16** [5] 152 (1937). R.F.REA

Refractory mortars. J. G. DE VOOGD. *Het Gas*, **55**, 443–52 (1935); *Chem. Abs.*, **30**, 5379 (1936).

Silicon carbide and its application to refractories. NORMAN GRIFFITHS. *Chem. Eng. & Mining Rev.*, **29** [339] 122–24 (1936).—SiC is produced in an electric resistor-type furnace. The charge consists of petroleum coke (ash not more than 0.4%), ground quartz, sawdust (to give porosity), and a little NaCl. The firing time is 36 hours and the maximum temperature 2250°C, the furnace consuming 1200 to 3000 h.p. After grading, the composition of the SiC is SiC 98, Fe 0.3, Al 0.05 to 0.12, and surface Si 0.35 to 0.6%. The firesand in the crust has the composition SiC 90, FeO 0.15, Al_2O_3 0.53, and the remainder siloxicon (SiO_yC_z). The fusion point of SiC is more than 2000°C, specific gravity is 3.1 to 3.2, and Mohs hardness is more than 9. SiC refractories may be divided into two groups: (1) preformed shapes, such as brick, tile, and muffles; and (2) cements and plastics which bond on firing *in situ*. Carbolox, containing 90% SiC, is an example of the bonded carbide. H.H.S.

Sintered magnesite: II, Sintering process. K. KONOPICKY. *Ber. Deut. Keram. Ges.*, **18** [3] 97–105 (1937).—The sintering of magnesia mixes containing iron oxide was studied. The lowest sintering temperature was obtained with a mixture of MgO, Fe_2O_3, and CaO. The porosity of the sinters decreases (at the same firing temperature) with increasing content of CaO. Sinters produced from a mixture of MgO and calcium ferrites have a sintering temperature between 1300° and 1400° and a dense structure. The physical values of this sinter are more favorable than those of sintered mixes of the individual constituents of the same analytical composition. As the firing temperature of mixes of the individual constituents is raised, the magnesia compounds are produced first, with a final decomposition in the direction of equilibrium but without attaining equilibrium. The equilibrium can be determined by a study of the MgO–Fe_2O_3–CaO–SiO_2 diagram. MgO can take into solution a considerable amount of $MgO \cdot Fe_2O_3$ at high temperatures. This tends toward inhomogeneity of cooling of the melt. The mosslike distribution of magnesium ferrite in periclase crystals, analogous to perthitic structure, is the result of the reseparation of the dissolved magnesium ferrite on cooling. For Part I see *Ceram. Abs.*, **16** [10] 313 (1937). E.J.V.

Studying and controlling refractory products. M. BONNOT. *Usine*, **46** [38] 35 (1937).—B. describes briefly the apparatus used and principles involved in determining the physical and mechanical properties of refractories. M.H.

Super-refractory materials. G. SAUERMANN. *Ber. Deut. Keram. Ges.*, **18** [2] 74–86 (1937).—S. lists a series of metals, carbides, nitrides, oxides, and minerals which have very high melting points, and discusses super-refractories made of blends and mixes or by various treatments of these materials. E.J.V.

Thermal insulating. EZER GRIFFITHS. *Heating & Ventilating Engr.*, **7** [77] 166–70; [78] 222–28; [79] 270–76 (1933–34); abstracted in *Sprechsaal*, **68** [19] 294–95 (1935).—The insulating properties of cork, wood, kiesel-

guhr, cellular concrete, "fibrox," and fibrous asbestos are discussed in detail. M.V.C.

Tridymite silica brick from crystalline quartzites. G. D. CHERNOUS. *Ogneupory*, **4**, 197–204 (1936); *Chem. Abs.*, **30**, 6906 (1936).—A trial lot of silica brick from crystalline quartzites was prepared with an addition of a frit prepared from Na_2CO_3, iron ore, and sand, containing 0.5% Na_2O and 1.2% Fe_2O_3. Fully tridymitized silica brick were obtained under ordinary commercial conditions.

Tridymitization of silica brick. A. A. CHADEYRON AND W. J. REES. *Refrac. Materials Joint Comm., Inst. Gas Engrs., 28th Rept.*, pp. 68–71 (1937).—The effect of additions of sodium and calcium phosphate to silica-brick batches was investigated. Sodium metaphosphate gave indications of increasing the tridymite content and calcium metaphosphate tended to favor the formation of cristobalite. See *Ceram. Abs.*, **15** [10] 304 (1936). R.F.REA

Working of graphite crucibles. EDMUND T. RICHARDS. *Feuerungstechnik*, **25** [5] 154–58 (1937).—R. describes German graphite deposits and their use in the manufacture of crucibles. The pretreatment of crucibles before use, such as storing, drying, and calcining, is discussed. The resistance of crucibles increases at first with the number of melts (usually after the first 10 melts). Various special precautions are required when using coke, gas, or oil firing. There is a definite relationship between the size of the crucible and furnace. Directions for charging the material to be melted and other related data are given. M.V.C.

BOOK

Manual of A.S.T.M. Standards on Refractory Materials. ANON. American Society for Testing Materials, Philadelphia, Pa. 180 pp. Price, paper cover $1.25, cloth $1.60. This volume brings together in compact convenient form all A.S.T.M. standards pertaining to refractories. This latest edition includes the 1937 revision of the methods for interpretation of refractory test data and information comprising industrial surveys showing service conditions of refractories in important consuming industries. R.A.HEINDL

PATENTS

Ceramic patching cement. J. M. MCKINLEY AND W. K. CARTER (National Aluminate Corp.). U. S. 2,102,327, Dec. 14, 1937 (Sept. 25, 1933; Sept. 30, 1935). A refractory patching cement comprises grog, clay, and about 1% of sodium aluminate.

Crucible. R. R. WICKLEIN. U. S. 2,099,043, Nov. 16, 1937 (Aug. 3, 1936).

Manufacture of refractory brick. KINGSCLIFFE INSULATING PRODUCTS, LTD., AND A. MARSHALL. Brit. 474,-891, Nov. 24, 1937 (April 20, 1937).

Process of producing pure alumina and crude potassium sulfate from alunite. SADAO YONEMURA, TSURUJI OKAZAWA, AND KOTA OSADA (Nihon Denki Kogyo Kabushiki Kaisha). U. S. 2,099,360, Nov. 16, 1937 (May 24, 1935). A process for producing substantially pure alumina and crude potassium sulfate from alunite consists in pulverizing the alunite, adding thereto a 20% to 50% solution of caustic potash, the quantity of potash being sufficient to form potassium sulfate with the sulfur trioxide combined with the alumina in the alunite plus a quantity equal to 1 to 1.5 times the quantity of alumina, heating the solution to 100° to 180°C while agitating it until the sulfur trioxide and alumina are converted, respectively, into potassium sulfate and potassium aluminate, cooling the solution to precipitate the potassium sulfate, filtering off the precipitated potassium sulfate together with the insoluble silicic acid and other insoluble residues, adding to the filtrate a quantity of water equal to the quantity of filtrate and in addition seed crystals of aluminum hydroxide, agitating the solution to precipitate aluminum hydroxide, filtering off the precipitate, and finally calcining the aluminum hydroxide to produce alumina.

Refractory. R. G. LEMMERMAN (Ferro Engineering Co.). U. S. 2,099,342, Nov. 16, 1937 (June 29, 1934). In a molded and dried refractory having a water-glass binder, the refractory comprises shale fired to provide porosity and an aggregate chemically inert to the water glass, the shale and aggregate constituting together from 90% to 99% by weight of the entire refractory.

Refractory products. NON-METALLIC MINERALS, INC. Brit. 475,508, Dec. 1, 1937 (Sept. 16, 1935).

Terra Cotta

Action of atmospheric agencies on building materials. F. H. CAMPBELL. *Chem. Eng. & Mining Rev.*, **29** [348] 455–56 (1937).—Quoting first the work in England of A. P. Laurie, R. C. Macfie, and others on the destructive effect of SO_2 in urban atmospheres on buildings, C. gives his analyses of Melbourne city air from two places during two winter months. The average SO_3 was 0.12 p.p.m., maximum 0.32, and minimum 0.05. H.H.S.

Air conditioning influences building design. J. H. WALKER. *Heating, Piping & Air Conditioning*, **9** [10] 599–602 (1937).—With air conditioning and adequate artificial lighting, proximity to windows is no longer a requirement, and office buildings may take the simple and economical parallelepiped form. The use of glass brick in the exterior walls produces a translucent wall which admits large amounts of daylight. Its winter heat loss is reasonably low, air infiltration is negligible, and heat gain in summer is much less than with ordinary unshaded windows. A building with design based on these facts, now being erected by the Detroit Edison Company, is described. There are no light courts. Glass brick are used in exterior walls, and the air-conditioning system operates 12 months of the year. 3 figs., 1 table. J.L.G.

Blue smoking of roof brick. K. ZIMMERMANN. *Ber. Deut. Keram. Ges.*, **18** [3] 110–20 (1937).—The blue smoking of roof brick has been attributed to the reduction of iron compounds in the brick and the decomposition of CO_2 to carbon in graphitic form. A chemical analysis of blue-smoked brick showed that the color obtained depends on the degree of reduction of the Fe_2O_3 in the brick and that in the lighter gray and silver colored brick there is a low percentage of carbon. Tests made on clays of varying composition to determine the degree of reduction of iron compounds by the presence of different gases and how

the formation of graphitic carbon can be controlled are described. See "Engobing—," *Ceram. Abs.*, **16** [7] 210 (1937). E.J.V.

Manufacture of salt-glazed stoneware pipes and fittings: XXIX. A. COULHON. Translated in *Brit. Clayworker*, **46** [547] 254–55 (1937).—C. describes an installation of a stoneware-pipe factory, beginning with the selection of a site to the plant layout and machinery required for efficient operation. See *Ceram. Abs.*, **17** [1] 17, 25 (1938). R.A.H.

Obtaining crystalline glazes for facing the Moscow subway. G. YU. ZHUKOVSKIĬ AND B. V. LYUL'EV. *Stroitel. Materialy*, **1937**, No. 7, pp. 30–36.—The tile must be white and fired at 1150° to avoid deformations in the second firing. Large crystals can be obtained by using 20 to 25% (0.5 to 0.75 mol.) of zinc oxide, the composition of the glaze playing no part. The silica content should be 1.0 to 2.0 mol., and the boron anhydride content 0.3 mol. The charge must be thoroughly mixed with mechanical mixers and the mixing controlled. All components must be finely ground. Quartz grains can attain a size of 0.1 to 0.5 mm., and the moisture content of the charge may be 1 to 5%. The frit is melted in crucibles or pots in a weak oxidizing flame at 1200°. It is ground in porcelain mills to the size of 0.1 mm.; 30 to 35% water and 0.5 to 2% pigment are added. The tile is glazed mechanically or manually in a $1^1/_2$-mm. layer. The firing is done in horizontal position, according to a strict schedule, in a weak oxidizing flame. See *Ceram. Abs.*, **16** [11] 327 (1937). P.B.&E.S.

PATENTS

Manufacture of fired clay slabs. J. A. BARBOUR AND SOUTHHOOK POTTERIES, LTD. Brit. 474,720, Nov. 17, 1937 (Jan. 30, 1937).

Manufacturing composite vitreous tile and concrete staves. P. C. FISH. U. S. 2,101,992, Dec. 14, 1937 (Aug. 1, 1931). The method of forming interfitting vitreous tile staves comprises forming a vitreous tile, firing it, molding a concrete tongue on one edge, and molding on the opposite edge a concrete groove adapted to receive a similar tongue.

Tile roofing. HAROLD GIMENO. U. S. 2,100,505, Nov. 30, 1937 (March 15, 1937). In clay tile roofing, the combination with the ridge purlin, the underlay, and the rows of cover clay tile mounted on the underlay, of metal pan strips, one common to each two adjacent rows of cover tile, on which strips the tile rest unconnected, in view of which one or more tile may be removed and replaced without affecting the pan strips, and means to secure the pan strips in place so as to leave a free and unobstructed drain way beneath the tile between their longitudinal edges and the sides of the pan strips.

Whiteware

Basic technical progress in the porcelain industry. Is this industry being revolutionized by the vacuum press? OTTO MANFRED. *Sprechsaal*, **70** [23] 299–300 (1937).—This is a discussion of a series of articles (with references) related to the operation of vacuum presses. See *Ceram. Abs.*, **15** [10] 308 (1936). M.V.C.

Ceramic insulating material for high frequency. H. HANDREK. *Z. Ver. Deut. Ing.*, **78**, 1411–49 (1934); abstracted in *Chem. Zentr.*, **1935**, **i**, 1748.—A description is given of the application and physical properties of present-day ceramic insulating materials with low dielectric losses and high dielectric constants. See *Ceram. Abs.*, **16** [1] 25 (1937). M.V.C.

Ceramic ware and the chemist. ANON. *Chem. & Ind.*, **56** [42] 922–23 (1937).—An outline is given of some of the recent developments in stoneware and porcelain in Great Britain. G.R.S.

Difference between porcelain and bone china. J. F. GRIMSON. *Pottery & Glass Rec.*, **19** [11] 291 (1937).—Porcelain is made of kaolin (china clay) and a vitrifiable material similar to china stone (pegmatite). Such a mixture fired in English kilns would produce ware of an unpleasant color. By adding a large proportion of bone ash, white china is produced. Porcelain is fired in a reducing atmosphere and china in an oxidizing atmosphere. In porcelain the unglazed ware is heated to a dull red only, but the body and glaze are fired at a high temperature (1350° to 1410°C). China is fired hard (1300°C) before glazing and at a much lower temperature (1100°C) when glazed. A.B.S.

Electrical resistance of porcelain. S. MORIYASU. *Jour. Japan. Ceram. Assn.*, **44**, 856 (1936); *Trans. Ceram. Soc.*, **36** [3] 24A (1937).—The resistivity of the quartz-feldspar-kaolin system has been determined, and the relation between the resistivity and the composition of the bodies is discussed.

Errors in present methods of proportioning raw materials in potteries and a reliable method. J. ISOBE, T. FUKAGAWA, AND S. KONDO. *Jour. Japan. Ceram. Assn.*, **43**, 715 (1935); *Trans. Ceram. Soc.*, **35**, 10A (1936).—The present methods of proportioning ceramic raw materials are classified, and the unavoidable errors in dry methods are discussed from a scientific standpoint.

Future of the china trade. HAROLD J. PLANT. *Pottery & Glass Rec.*, **19** [11] 294 (1937).—The future of the china trade in England will be difficult, but there is no real need for anxiety if efficiency is combined with optimism and common sense. A tremendous change has taken place in the last 20 years, for an enormous amount of mechanism has replaced hand labor, and many common defects have been eliminated. Casting has largely replaced throwing and turning, and many improvements have been made in machines and ovens. Developments are likely to proceed still more rapidly in the future. It is unlikely that earthenware or porcelain will replace china except in the cheapest qualities made for multiple and chain stores. A.B.S.

Glost warping of glazed ware. S. KONDO, C. KAWASHIMA, AND A. WAKABAYASHI. *Jour. Japan. Ceram. Assn.*, **43**, 793 (1935); *Trans. Ceram. Soc.*, **35**, 11A (1936).—The results of preliminary experiments are reported. Inasmuch as only one test piece was used for most tests, no definite conclusions are drawn. The ware under test was feldspathic faience, fired biscuit at 1200° and glost at 1100°. Warpage increased with increase in time of glost firing, thickness of glaze, and fluidity of the molten

glaze and decreased with increase in molding pressure. It appeared to be decreased by plastic kaolin and pyrophyllite in the body and to be intensified by kaolin, quartz, and feldspar.

Physical properties of steatite products. S. Ito. *Jour. Japan. Ceram. Assn.*, **43,** 646 (1935); *Trans. Ceram. Soc.*, **35,** 15A (1936).—The effects of varying molding pressures and amounts of bond added to a nonplastic steatite on its physical properties were studied. With no bond, the transverse strength varied directly with the pressure applied. With excess bond, the transverse strength of the fired product showed a rapid approach to a constant value with increasing molding pressure. With a moderate amount of bond, maximum and minimum values were found. The expansion coefficients of the fired products were constant, independent of the molding pressures. The cristobalite effect at about 270° had a maximum value for a definite molding pressure. Decreasing the amount of bond and increasing the pressure produced decreases in porosity, and lower porosities gave greater mechanical strengths than high porosities.

Quality in china. N. Elliott. *Pottery & Glass Rec.*, **19** [11] 289 (1937).—If the market for chinaware is to be maintained and increased, the highest standards of quality must be realized; otherwise, there is little advantage over buying earthenware. The finest chinaware is made in England; it is translucent, hard, and vitreous, and combines lightness, toughness, and wearing power with the highest aesthetic qualities. Continental china chips more easily and the range of colors does not afford the softness and richness of effects obtained on English china. The best English china consists of 50% bone ash, 25% Cornish stone (pegmatite), and 25% china clay (kaolin). Cheap china can be made by using an inferior glaze, but the quality is spoiled. Some of the manufacturing processes suitable for earthenware, *e.g.*, jolleying, can not be used for china. The older, conventional type of decoration is preferred, and the use of printed ware is increasing. Cheap ware can be obtained by using overglaze instead of underglaze decorations, but, again, quality is lost. Quality depends almost equally on the skill of artists and of craftsmen. A.B.S.

Sanitary ware and its manufacture in Berlin. Bublitz. *Ber. Deut. Keram. Ges.*, **18** [5] 193–97 (1937).—A historical résumé of the beginning of production of sanitary porcelain in Berlin is given. Chemical porcelain ware produced in the early 1800's is also listed. E.J.V.

Zinc in glazed earthenware. W. Donovan. *Ann. Rept. New Zealand Dominion Analyst*, 1935; abstracted in *Analyst*, **62** [737] 309–10 (1937).—Zn equivalent to 0.4 g. per 100 cc. acid used was dissolved from a sample of glazed ovenware when treated at cooking temperatures for 30 minutes with *N* HCl. The zinc glaze was used to produce a mat surface. H.H.S.

PATENTS

Compounding ceramic products. J. G. A. Lefranc. U. S. 2,099,367, Nov. 16, 1937 (Feb. 4, 1935). A method for the manufacture of ceramic materials consists in preparing a binder by treating a calcic phosphate containing several calcic molecules by an acid, so as to bring back the phosphate to the state of an inferior calcic phosphate, the quantity of acid being such that there will be no excess of free acid, and mixing the binder with a nonplastic material.

Earthenware bodies. I. E. Sproat (R. T. Vanderbilt Co.). U. S. 20,555, Nov. 16, 1937 (Aug. 26, 1937); reissue of original U. S. 2,068,154 (*Ceram. Abs.*, **16** [4] 122 (1937)).

Electric bushing insulators of the condenser type. British Thomson-Houston Co., Ltd. Brit. 474,703, Nov. 17, 1937 (Nov. 9, 1935).

Producing vacuum-tight joints between metallic and insulating bodies. British Thomson-Houston Co., Ltd. Brit. 474,575, Nov. 17, 1937 (April 8, 1936).

Saucer for cup. Hyman Klayp. U. S. 2,099,741, Nov. 23, 1937 (May 20, 1936). In a saucer for a cup, the saucer has a concavo-convex section and has provided, adjacent and beyond the central portion of the concave surface upon which a cup is normally supported, means for entering and engaging the top of the cup so as to prevent relative movement when the saucer is inverted and placed on the top of the cup.

Sintering finely powdered materials. F. Krupp Akt.-Ges. Brit. 474,574, Nov. 17, 1937 (July 24, 1936).

Waterclosets. Briggs Mfg. Co. Brit. 475,017, Nov. 24, 1937 (April 6, 1936).

Equipment and Apparatus

Apparatus for determining gas permeability. N. A. Kogan and L. I. Levi. *Liteinoe Delo*, **7** [11] 39 (1936); abstracted in *Chem. Zentr.*, **1937, ii,** 2400.—A short description of an apparatus used for determining gas permeability of porous bodies is given. M.V.C.

Applications of the expansion pyrometer. P. Chevenard. *Génie Civil*, **107,** 424–27 (1935); *Chem. Abs.*, **30,** 1266 (1936).—Construction improvements have made this type of pyrometer sufficiently robust for factory use, either as a control apparatus or as an automatic heat regulator. Drawings and photographs explain the construction and working principles of the pyrometers and their use in grain-growth studies.

Automatic control in examination of mineral suspensions. L. V. Lyutin, V. A. Kiryushkin, and I. M. Kormer. *Mineral. Syr'e*, **11** [5] 44–48 (1936); *Chem. Abs.*, **30,** 6991 (1936).—A laboratory device for automatic sampling, a continuous viscometer, and nomograms for calculating the results of sedimentation analysis are illustrated and described.

Brass centrifuge for mineral separation according to specific gravity. H. Andrée and G. Claus. *Zentr. Mineral. Geol.*, **1935A,** pp. 150–54; abstracted in *Chem. Zentr.*, **1935, ii,** 252.—Brass centrifuges are distinguished by their great resistance and capacity. Brass is resistant to organic liquids used for the separation. M.V.C.

Camera for low-temperature X-ray diffraction work. Barbara Ruheman. *Physik. Z. Sowjetunion*, **7,** 572–82 (1935); *Chem. Abs.*, **29,** 7707 (1935).—Only the specimen, not the photographic film, is in vacuum; a window 8 × 30

mm., made of 12-micron cellulose acetate, withstands the atmospheric pressure. A small cold machine (Ruheman) permits holding the temperature constant to 0.1° in the range from liquid H_2 to room temperature for exposures of several hours.

Central lubrication under pressure for brick machines. M. NUSSBAUMER. *Brit. Clayworker*, **46** [547] 256–60 (1937).—N. describes methods of lubrication with grease or oil, which are entirely new and have not hitherto been adopted in machines for brick and tile. The system has been applied with success in several industries, and the simplicity of its application to the pugmill is pointed out. R.A.H.

Clay handling. JOHN COOPER. *Chem. Eng. & Mining Rev.*, **29** [348] 443–44 (1937).—Recent improvements have simplified handling operations in clay winning. The excavator is now placed at the top of the bank instead of at the foot. The time taken to move driving gear and make level adjustments is much less than formerly; in one plant, using 192 ft. of sectional conveyers, the whole outfit was moved 10 ft. in 1 hr. Rubber belting is used instead of the steel slat band. Conveyers are constructed in unit lengths (12 ft.) of inverted troughing, and the troughs are joined by cover plates allowing inspection during working and stiffened by saddles placed under the idler brackets. Power required for the conveyers is 10 to 15 h.p. An English factory making 250,000 brick a week (50 hr.) required 1750 b.h.p., of which 70% was used in the excavator, 15% in the first conveyer, and 15% in the second belt. H.H.S.

Colorimeter. J. WOUDA. *Proc. Acad. Sci. Amsterdam*, **38** [6] 585–89 (1935); *Physik. Ber.*, **16** [21] 1982–83 (1935).—The disadvantages of the usually employed trichromatic and monochromatic colorimeters are explained, and a new method is described by which the energy distribution curve of the light emitted by the color to be measured is determined; from this curve, the location of the color in the color triangle is calculated. W. describes a simple apparatus to determine the energy distribution curve. M.H.

Comparative study of electric thermocouples. H. PÉCHEUX. *Rev. Gen. Sci.*, **48** [1] 17–22 (1937). R.W.D.

Development of spray drying. T. B. PHILIP. *Trans. Inst. Chem. Engrs.*, **13**, 107–20 (1936); *Brit. Chem. Abs.-B*, **56**, 1 (1937).—Spray drying, methods of recovering the dry product, and its properties and costs are discussed. The use of tinned steel as a material of construction for spray driers for the food industry is indicated.

Electric muffle furnaces for hardening steel. K. H. TWELE. *Eng. Progress*, **18** [10] 203–205 (1937).—T. briefly discusses the hardening of steel and the advantages of electric muffle furnaces in this work. Six types of such furnaces manufactured and used in Germany are described and illustrated. These include small muffles, chamber furnaces for annealing and casehardening, Silit(SiC)-chamber muffles, double-chamber muffles, and tempering muffles. Illustrated. J L.G.

Grinding ceramic materials in ball, pebble, rod, and tube mills. G. F. METZ. *Bull. Amer. Ceram. Soc.*, **16** [12] 461–67 (1937).

High degree of accuracy of the improved soil hydrometer used in the mechanical analysis of soils. G. J. BOUYOUCOS. *Soil Sci.*, **44** [4] 315–17 (1937).—The soil hydrometer, when placed in soil suspension that has been allowed to settle in order to produce differences in density with depth, indicates the same quantity of soil present as that in the same suspension when it is siphoned off and mixed to produce conditions of uniform density. The amount indicated is the same, within limits of experimental error, as that found by gravimetric determination. These facts establish conclusively the fact that the hydrometer method is practical and accurate. At the same time, they prove that certain criticisms of the method based on theoretical considerations are invalid. The improved type of hydrometer is described in *Ibid.*, **42**, 225–29 (1936). See *Ceram. Abs.*, **17** [1] 30 (1938). G.R.S.

Instrument for measuring the workability of clays. F. H. NORTON. *Jour. Amer. Ceram. Soc.*, **21** [1] 33–36 (1938).

Instrument for technical gas analysis. E. SCHIERHOLZ. *Glückauf*, **73** [38] 875–76 (1937).—A modification of the Orsat apparatus is described in which the combustion chamber is heated electrically. M.H.

Magnetic dilatometer. T. C. RICHARDS. *Iron & Steel Ind.*, **8**, 261–64 (April, 1935); *Jour. Iron & Steel Inst.* [London], **131** [1] 474 (1935).—In this form of dilatometer the expansion of the specimen is communicated to a pendulum, the lower end of which moves in the magnetic field across a small gap in a permanent magnet. Lateral displacement of the soft iron element within the magnetic field results in rotation. A mirror and light source enable visual or photographic records to be obtained; the magnification is high, and quite small anomalies may be detected.

Marathon steels. B. WAESER. *Chem. Apparat*, **24** [18] 297–98 (1937).—W. reviews compositions and properties of Cr-Mo-V, Cr-Ni-Mo, and magnetic Co-Ni-Al steels for use in chemical apparatus and machinery for conveyers, crushers, and separators. M.H.

Meter for clays and mineral dusts; its applications. E. G. RICHARDSON. *Sands, Clays & Minerals*, **3** [2] 129–31 (1937).—The apparatus is used to determine the relative number of particles in a solid system such as a mineral dust consisting of a heterogeneous collection of substances of varying diameters, from several millimeters to 1 micron. The glass settling tank for a sedimentation method is blackened except for a small space where the beam of light passes horizontally from a lamp to a photoelectric cell. The intensity of the beam changes according to the state of the liquid, *i.e.*, to the amount of suspended matter at the plane of the beam, so that a continuous curve is recorded. The time taken by silica particles to fall through 1 ft. at 60°F was as follows:

Size (microns)	In air	In water
10	32 sec.	20 min.
1	54 min.	33.3 hr.
0.1	90 hr.	Infinity

M.H.

Optical pyrometer. L. P. *Rev. Industrielle*, **67** [2331] 78–79 (1937).—This apparatus involves the absorption of all radiations emitted by the hot body except red and green rays. The selective absorption is realized by means of two independent wedges sliding in the visual field of

the telescope which appears more or less yellowish. Comparison with the light emitted by a standard source of luminous radiations permits the determination of the temperature of the hot body. R.W.D.

Portable thermocouple potentiometer. D. R. BARBER. *Jour. Sci. Instruments*, **14** [10] 343–46 (1937).—The construction and operation of a portable thermocouple potentiometer employing a copper-constantan couple are described. The instrument indicates temperatures direct from the potentiometer scale over the range 20 to 46°C to ± 0.1°C. Illustrated. J.L.G.

Preparation of colloidal mineral colors. PIERCE M. TRAVIS. *Bull. Amer. Ceram. Soc.*, **16** [12] 467–71 (1937).

Progress in vacuum technique. H. EBERT. *Glas & Apparat*, **18** [13–14] 129–32, 146, 149–50 (1937).—E. reviews patents relating to methods and apparatus. M.H.

Pyrometer. C. J. TAGLIABUE MFG. CO. *Steel*, **99**, 74 (Sept. 7, 1936).—A new 2- and 3-position recording and controlling pyrometer is illustrated. H.E.S.

Rapid drying with pulsating circulating air. S. KIESSKALT. *Z. Ver. Deut. Ing.*, **78** [7] 217–20 (1934); abstracted in *Mech. Eng.*, **56** [5] 302 (1934). F.G.H.

Rational psychromatics. E. VERNON HILL. *Heating, Piping & Air Conditioning*, **9** [10] 621–24 (1937).—H. discusses Fahrenheit's original thermometer with 24 divisions from 0° to 98.6°F and advocates graduating the dry-bulb thermometer with this scale to simplify calculations. On the new scale, 100°F would then be 24.1, 200° would be 48.2, etc. Since multiplying the specific heat of air, 0.241, by the present Fahrenheit degrees gives this original scale, each degree on the advocated scale represents the sensible heat in 1 lb. of air. H. then proposes graduating the wet-bulb thermometer in degrees of total heat. In the latter case the graduations will not be uniform as on the dry-bulb thermometer. With a psychrometer so constructed, dry-bulb readings are the sensible heat in B.t.u. / lb. of air; wet-bulb readings are the total heat in B.t.u. / lb. of air. The difference between the two readings is the latent heat. The dew-point scale is then graduated from 0 up in B.t.u. degrees of latent heat with 0 as the latent heat of dry air. The construction of a simplified psychrometric chart using the proposed scales is described and illustrated. Air mixtures, cooling problems, and heat ratio are considered with the aid of examples. J.L.G.

Safety goggles. AMERICAN OPTICAL CO. *Steel*, **99**, 64 (Oct. 5, 1936). H.E.S.

Simple high-temperature gas burner. JOHN J. REIMER AND T. W. DRUMMOND. *Bull. Amer. Ceram. Soc.*, **16** [12] 477 (1937).

Temperature measurement and regulation. FRANZ RITTER. *Oesterr. Chem.-Ztg.*, **38**, 154–57 (1935); abstracted in *Chem. Zentr.*, **1935, ii**, 3680.—R. describes various types of thermometers, pyrometers, thermoelements (up to 2000°C), resistance thermometers, etc., and temperature regulators of little-known types. M.V.C.

Temperature regulation of electrical industrial furnaces. L. MOENNICH. *Elektrowärme*, **7** [11] 233–42 (1937).—M. gives a comprehensive review and description of the various systems and instruments in use. M.H.

Thermocouples and protecting tubes. ANON. *Kachestvennaya Stal*, **4** [6] 57 (1936).—For high-temperature control by heat-treating alloy steels, platinum-platinum rhodium thermocouples are not suitable for continuous control of temperature from 1000 to 1250°; this control is carried out by radiation pyrometers. The Electrostal steel works uses, for such temperature control, a thermocouple which consists of one pure nickel wire and the other thermoelectrode wire of chromium alloy steel E159 (28 to 32% of chromium). This thermocouple is fireproof; up to 1000°C its life is about 1 year to 14 months, and up to 1250°, 2 to 3 months. The e.m.f. of this thermocouple is about twice as much as that of the Pt-Pt Rh thermocouple. The chromium alloy steel E159 with 28 to 32% chromium is also used for protecting tubes which, at temperatures of 1200 to 1300°C, have a life of 2 to 3 months. They are satisfactorily resistant to corrosion in salt baths at temperatures up to 1000°C. B.E.K.

PATENTS

Apparatus for air flotation separation. E. M. RUSK. U. S. 2,101,295, Dec. 7, 1937 (Sept. 8, 1933).

Apparatus for separation of coal, etc. K. C. APPLEYARD (Birtley Co., Ltd.). U. S. 2,101,381, Dec. 7, 1937 (Sept. 13, 1933).

Applying layers of base metal upon ceramic bodies. SIEMENS & HALSKE AKT.-GES. Brit. 475,935, Dec. 8, 1937 (July 12, 1935).

Atomizer. W. C. GRAHAM. U. S. 2,102,147, Dec. 14, 1937 (March 15, 1937). A spray nozzle comprises, in combination, a sprayer tip having an orifice and tangential slots communicating therewith, a whirl chamber behind the sprayer tip and communicating with the slots, and means for delivering whirling liquid to the whirl chamber.

Automatic control of grinding and crushing mills. C. F. L. RODER. Brit. 475,421, Dec. 1, 1937 (May 18, 1936).

Automatic weighing and feeding machine. W. M. RYAN AND J. W. BOLD (Ryan Coffee Corp.). U. S. 2,100,874, Nov. 30, 1937 (Aug. 21, 1934).—Apparatus of the type described comprises weighing mechanism having a series of independently actuated weighing buckets and discharge means therefor, individual supply means for each of the buckets, means to close the supply means when the buckets have a predetermined weight of material and timed means to actuate the discharge means simultaneously, means actuated by predetermined weight of material in the buckets to control the discharge means, and means to move a series of containers corresponding to the series of weighing buckets into position to receive material from the buckets between each discharging interval in timed cyclic sequence.

Centrifugal apparatus for separating and collecting dust, etc., from air and gases. C. H. W. CHELTNAM, C. H. CHELTNAM, AND GENERAL ELECTRIC CO., LTD. Brit. 475,126, Nov. 24, 1937 (May 14, 1936).

Centrifugal separating machines. J. S. PECKER. Brit. 474,578, Nov. 17, 1937 (July 8, 1936).

Colorimeter. GUSTAVE FASSIN (Bausch & Lomb Optical Co.). U. S. 2,101,934, Dec. 14, 1937 (Feb. 25, 1936). GUSTAVE FASSIN AND J. R. MILES (Bausch & Lomb Optical Co.). U. S. 2,101,933, Dec. 14, 1937(Feb. 25, 1936).

Froth-flotation concentration of minerals. F. R. TATE

(Potash Co. of America). Brit. 475,725, Dec. 8, 1937 (Feb. 20, 1936).

Froth-flotation concentration of ores. F. B. DEHN (Potash Co. of America). Brit. 475,789, Dec. 8, 1937 (Feb. 25, 1936).

Hammers for impact-breaking or crushing machines. G. H. PATTINSON. Brit. 475,430, Dec. 1, 1937 (June 2, 1936).

Ignition apparatus for closed-system fluent-combustible burners. J. W. HAYS. U. S. 2,102,153, Dec. 14, 1937 (March 18, 1933). A heater, adapted to burn a fluent explosive mixture, comprises a combustion chamber, a refractory catalyst in the combustion chamber, means for supplying an explosive mixture to the combustion chamber, a recessed housing opening into the combustion chamber, a vent from the housing to the outside air, a movable stopper in the vent, and a hot-wire igniting element in the housing.

Joining ceramic bodies to one another or to metallic bodies. SIEMENS & HALSKE AKT.-GES. Brit. 475,878, Dec. 8, 1937 (June 19, 1935).

Machine for mixing granular or pulverulent materials. RUNFOLD SAND & TILE CO., LTD., AND H. A. WILKINSON. Brit. 475,519, Dec. 1, 1937 (May 21, 1936).

Machine for polishing granite, marble, terrazzo, glass, etc. H. M. HAY. Brit. 474,883, Nov. 24, 1937 (May 9, 1936).

Machine for producing tile. H. HAWKINS, LTD., AND C. L. HAWKINS. Brit. 475,367, Dec. 1, 1937 (June 2, 1936).

Means for automatically weighing predetermined quantities of discrete materials. EDWIN COUBRAY. U. S. 2,101,384, Dec. 7, 1937 (March 26, 1936).

Mixing and grinding mill. OSKAR SCHULTHESS AND CASIMIR THEILER (Society of Chemical Industry in Basle). U. S. 2,100,599, Nov. 30, 1937 (July 24, 1934). A mixing mill with arrangement for dust-free discharge of the mixed material comprises a rotary mixing drum having an aperture for the exit of the goods in its peripheral wall, a trough located outside the periphery of the drum and rigidly connected to the drum wall opposite the exit aperture, the trough extending longitudinally of the axis of the drum, the trough having a discharge opening in the wall thereof, a rotary conveyer within the trough to convey the material to the discharge opening, freely movable mixing and grinding bodies within the drum of larger dimension than the aperture thereby being prevented from entering the trough, driving means for rotating the drum together with the trough around the axis of the drum, and independent driving means for rotating the conveyer about its own axis when the drum is at rest.

Powdered material applying apparatus. D. A. S. LAING (Western Electric Co., Inc.). U. S. 2,100,399, Nov. 30, 1937 (April 17, 1936).—An apparatus for applying powdered material to moving articles has a table for supporting a supply of the material in the path of the moving articles, a hopper for maintaining the supply of material on the table, and means for moving the hopper and table in a direction transverse to the direction of movement of the articles.

Presses for molding tile, etc. E. B. COLLINGHAM AND C. J. A. OWEN. Brit. 475,916, Dec. 8, 1937 (July 17, 1936).

Separation into classes of mixed materials of different electrical conductivities. BIRTLEY CO., LTD., K. C. APPLEYARD, AND S. D. POLLITT. Brit. 475,645, Dec. 8, 1937 (April 18, 1936).

Sintering system. E. W. SHALLOCK (American Ore Reclamation Co.). U. S. 2,100,878, Nov. 30, 1937 (May 8, 1935). In a system for supplying granular-like materials having different rates of flow for producing a mixture thereof in desired proportions, a plurality of bins containing the materials, a conveyer, and remotely controlled electrically actuated means comprising control rheostats and effective for delivering materials from the bins to the conveyer in predetermined proportionate amounts and selectively varying at will the rate of delivery of material from the individual bins during and independently of the rate of continued delivery of materials from the remainder of the bins.

Spray-drying and solvent recovery system. CARBIDE & CARBON CHEMICALS CORP. Brit. 475,635, Dec. 8, 1937 (June 19, 1936).

Treating material by heat. F. B. DEHN (American Potash & Chemical Corp.). Brit. 475,041, Nov. 24, 1937 (May 8, 1936).

Vibratory sieves. K. GROPPEL. Brit. 475,638, Dec. 8, 1937 (June 11, 1937).

Kilns, Furnaces, Fuels, and Combustion

Combustion. H. A. FELLS. *Gas World* [Ind. Gas Supp.], **102,** 10–14 (May 18, 1935); *Jour. Iron & Steel Inst.* [London], **132** [2] 334 (1935).—F. enumerates the principal factors which govern the application of town gas to industrial heating, especially in regard to the process of combustion. The optimum air to gas ratio, the influence of preheating, and the production of luminous flames are considered. The process of combustion is dealt with, reference being made to the nature of the furnace atmosphere and of the combustion products.

Contact phenomena in silicon-carbide resistors. I. V. KURCHATOV, T. Z. KOSTINA, AND L. I. RUSINOV. *Phys. Z. Sowjetunion,* **7,** 129–54 (1935); abstracted in *Chem. Zentr.,* **1935, ii,** 2786.—Studies were made of semiconductor silicon-carbide resistors whose conductivity depends greatly on potential. See "Researches—," *Ceram. Abs.,* **14** [5] 118 (1935). M.V.C.

Electrical furnace with ceramic Silit resistance. S. M. DOROGOV. *Zavodskaya Lab.,* **6,** 869–72 (1937). P.B. & E.S.

Electrically fired ceramic kilns. A. BAIER. *Keram. Rundschau,* **45** [13] 139–41 (1937).—The price of the kw.-hr. (not higher than 2.5 pf.) and convection processes are first to be considered. Kilns may be fixed or transportable. A kiln 80 by 50 by 80 cm., equipped with 50 resistors of 500 watts each, is described for glaze firing. Firing at cones 07*a* to 06*a* in 12 hr. requires 200 to 220 kw.-hr. The 6 inner faces are heated. There is a grog brick lining,

and further insulation of diatomite. The construction is practically airproof; the ware is of excellent quality. The regulation is secured by the separation of the resistors in groups. The price of construction is rather high, and amortization is not less than 25%. Illustrated. F.E.V.

Failure of a gold fuse in contact with nickel-chromium alloy. M. C. CAPLAN. *Jour. Inst. Metals*, **57** [Advance copy No. 707] 331–33 (June, 1935); *Metals & Alloys*, **6** [11] MA451 (1935).—The failure of a Au fuse to operate at the correct temperature was found to be due to diffusion taking place between the Au link and the Ni-Cr connection at a temperature of 950 to 1000°C. An alloy of lower melting point is formed that offers little resistance to oxidation; the Au link finally becomes disintegrated and converted to a cindery residue.

Gas producers. H. GUILLON. *Chaleur & Ind.*, **16**, 483–84, 518–24, 560–62 (1935); **17**, 153–56, 191–97, 230–34 (1936); *Jour. Soc. Glass Tech.*, **20** [77] A325 (1936).—G. gives a detailed series of articles on the theoretical and practical aspects of gas producers. A description is given of the development in design of the modern gas producer from the Siemen inclined grate type to the latest Morgan, Heurley, Stein, and Sauvageot gas-making machines.

Heat conduction, convection, and radiation. ERNST SCHMIDT. *Physik*, **5** [4] 101–17 (1937).—S. reviews recent international literature and research data dealing with heat transfer through gases, liquids, and solids. 100 references. L.E.T.

Ceramic firing: VII, Steatite, data and methods used; VIII, Effect of firing conditions on structural changes; IX, Effect of firing on sintering processes; X, Effect of firing on the properties of steatite; XI, Summary and conclusions. OTTO KRAUSE AND ERNST JÄKEL. *Sprechsaal*, **70** [34] 433–35; [35] 443–47; [36] 455–58; [37] 467–71; [38] 481–82 (1937).—From a systematic study of the effect of three factors of ceramic firing, (1) firing temperature, (2) duration of firing, and (3) furnace atmosphere, basic characteristics of steatite manufacture were developed which yield data for a technical development of electric firing of steatite products with an appropriate lowering of temperature peaks. For Part IV see *Ceram. Abs.*, **15** [8] 252 (1936). M.V.C.

Little known source of soluble salts. WALTER MARSCHNER. *Ziegelwelt*, **68**, 131 (1937); abstracted in *Chem. Zentr.*, **1937**, ii, 2055.—When firing hollow brick, furnace ashes should be removed as soon as possible because they contain salts combined with sulfuric acid which may be the cause of efflorescences. M.V.C.

Modern gas producers reflect advances in design and operation. COOPER-BESSEMER CORP. *Steel*, **99**, 59 (Aug. 17, 1936).—A modern producer is illustrated and diagrammed. H.E.S.

Protective coats for muffles and furnace walls in industrial furnaces. HUGO SCHULZE. *Glashütte*, **67** [37] 579–80 (1937).—S. discusses the application of various protecting coats to insure a greater durability of furnace linings. Mixtures of loam and salt of thick consistency, clay and borax, quartz sand, litharge, and fired borax are used successfully. A plastic and refractory mortar, "Qu-Chromatic," developed in the U. S., is discussed. M.V.C.

BULLETIN

Burning of Coal and Coke Treated with Small Quantities of Chemicals. P. NICHOLLS, W. E. RICE, B. A. LANDRY, AND W. T. REID. *U. S. Bur. Mines Bull.*, No. 404. 158 pp. Price 15¢. Tests to determine what effect preheating fuels with chemicals dissolved or suspended in water has on the burning of fuels, the fuel bed, and the ash are discussed. R.A.HEINDL

PATENTS

Continuous electric furnace for firing ceramic ware. SIEMENS-SCHUCKERTWERKE A.-G. (Carl T. Buff, inventor). Ger. 646,389, June 12, 1937; Cl. 80*c*. 5; *Chem. Abs.*, **31**, 6434 (1937).—A reducing atmosphere is produced in certain parts of the furnace by pushing rods of a carbonaceous fuel through holes in the roof or wall of the furnace.

Continuous kilns. A. GEYER. Brit. 475,409, Dec. 1, 1937 (March 13, 1936). F. M. HARTFORD. Brit. 474,576, Nov. 17, 1937 (April 13, 1935).

Manufacture and application of titanium dioxide products. H. DREYFUS. Brit. 475,356, Dec. 1, 1937 (May 14, 1936).

Muffle furnace. H. W. SPENCER AND L. S. DAVIS. U. S. 2,099,967, Nov. 23, 1937 (Oct. 8, 1935).—A muffle furnace construction comprises suspended arch refractory elements and muffle elements suspended from the arch elements to form a continuous muffle wall and affording passageways through which the products of combustion are intended to circulate.

Temperature controlled furnaces. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 475,706, Dec. 8, 1937 (Dec. 21, 1935).

Tunnel furnaces. SIEMENS-SCHUCKERTWERKE A.-G. (Carl T. Buff, inventor). Ger. 646,390, June 12, 1937; Cl. 80*c*. 5; *Chem. Abs.*, **31**, 6434 (1937).—To produce a reducing atmosphere in a section of a tunnel furnace, particularly in an electrically heated tunnel furnace for firing ceramic ware, each truck which conveys the goods through the furnace carries also a quantity of carbonaceous fuel in a vessel on which a cover is secured with the aid of a material which melts or softens at a predetermined temperature and thereby releases the cover.

Geology

Anion adsorption by soil colloids in relation to changes in free iron oxides. S. J. TOTH. *Soil Sci.*, **44** [4] 299–314 (1937).—The importance of free iron oxide content of soil colloids with reference to silicate and phosphate adsorption is pointed out. The removal of this constituent from soil colloids lessens the magnitude of adsorption and results in smaller increases in exchange capacity produced as the result of widening the acidoid-basoid ratio by the phosphate treatment. Fractions of the adsorbed phosphates displaced silicate ions from the soil colloids. The phosphate-treated colloids exhibited a more marked increase in exchange capacity and reductions in ultimate p_H than the silicate-treated colloids, even though the latter treatment generally resulted in a more marked anion ad-

sorption by the colloids. This was explained by the fact that the activity of the silicate ions is reduced at acid p_H values, and the greater adsorption of this ion, when compared to the retention of phosphates, was due to the precipitation of amorphous silica. G.R.S.

Artificial conversion of feldspars into pyrophyllite. R. SCHWARZ AND G. TRAGESER. *Naturwissenschaften*, **23**, 512 (1935); *Trans. Ceram. Soc.*, **35** [3] 19A (1936).—In a previous paper (*Naturwissenschaften*, **21**, 252 (1933); *Ceram. Abs.*, **13** [4] 100 (1934)) the conversion of feldspars and related minerals into kaolin by hydrothermal treatment with dilute HCl was described. In a similar manner, the synthetic preparation of pyrophyllite ($Al_2O_3 \cdot 4SiO_2 \cdot H_2O$) has been achieved by the conversion of orthoclase or anorthite in a pressure bomb at more than 400° with dilute HCl. The nature of the transformation, therefore, depends entirely upon temperature, and pyrophyllites are formed at temperatures exceeding 400°. See *ibid.*, **15** [3] 108 (1936).

Bentonite in industry. J. S. WILSON. *Sands, Clays & Minerals*, **3** [2] 149–52 (1937). M.H.

Calcic feldspar deposits of Minnesota. G. M. SCHWARTZ. *Bull. Amer. Ceram. Soc.*, **16** [12] 471–76 (1937).

Clay and kaolin of Piedmont (Italy). F. DE CARLI AND U. PASSARINI. *Ricerca Sci.*, [2] **8**, I [5–6] 196–205 (1937).—Geographical distribution and geological conditions of the deposits are described. M.H.

Clays. H. VIGNERON. *Nature* [Paris], No. 14, pp. 122–25 (1937).—The constitution of clays and their general properties are studied. R.W.D.

Crystal structure of aluminum arsenate, $AlAsO_4$: Contribution to the question of isomorphism of crystal types of silicon and pentavalent arsenic. F. MACHATSCHKI. *Z. Krist.*, **90**, 314–21 (1935); abstracted in *Chem. Zentr.*, **1935, ii**, 1661; see *Ceram. Abs.*, **16** [1] 43 (1937). M.V.C.

Crystal structure of aluminum phosphate, $AlPO_4$. H. F. HUTTENLOCHER. *Z. Krist.*, **90**, 508–16 (1935); abstracted in *Chem. Zentr.*, **1935, ii**, 1661. M.V.C.

Diatomites. L. PERRUCHE. *Nature* [Paris], No. 13, pp. 49–53; No. 14, pp. 111–17 (1937).—A general study on diatomites is presented. Illustrated. R.W.D.

Ease of decomposition in acid of German clays under different conditions. W. GUERTLER, P. BERGMANN, AND A. GEUTEBRUECK. *Metall & Erz*, **32**, 242–46 (1935); *Chem. Abs.*, **29**, 5999 (1935).—Clays can be classified according to the time required for decomposition in boiling 20% HCl. By treatment with HCl, clays yield about 80% of the earths originally present.

Extraction of quartz from the barite tailings of the Salair concentrator. A. S. SLADKOV. *Gorno-Obogatitel. Zhur.*, No. 8, p. 35 (1937).—The tailings from the barite flotation contained 29.94% $BaSO_4$ and 61.46% SiO_2. They were concentrated on tables, yielding a quartz concentrate of 92.48% SiO_2 and a barite concentrate containing 88.48% $BaSO_4$. The composition of the quartz concentrate is SiO_2 92.48, $BaSO_4$ 4.92, Al_2O_3 0.90, Fe_2O_3 0.69, Fe 0.48, Zn 0.65, Cu 0.06, Pb 0.22, MgO 0.29, and CaO 1.15%. The concentrate can be used in glass and porcelain works. A quartz section is now under construction at the Salair plant, and a glass-porcelain factory is being planned which will be the chief consumer of the quartz concentrate. The concentrate will also be used for local metallurgical and construction needs because of the insufficiency of pure quartz sands in the Kuznets Basin. B.Z.K.

Ice as agent of rock weathering: a discussion. OLIVER R. GRAWE. *Jour. Geol.*, **44** [2] 173–82 (1936).—The mechanics involved when water changes to ice in a rock has been slightly understood and only qualitatively discussed. Geologists state that the force exerted is 150 to 34,000 lb./sq. in. Critical data on ice are scarce. Pressure of freezing water depresses the freezing point and liberates heat. Bridgman has shown that the highest possible pressure of water freezing in rock is about 30,000 lb. / sq. in., but certain rigorous conditions must be simultaneously established. Taber's studies of frost heaving afford many pertinent data. Under the variable conditions obtaining in nature, G. states "that the force exerted when water freezes in a rock can not be stated as a definite value unless the conditions under which the process takes place are also stated." The process is a complex one. Maximum pressure (2045 atm.) is produced only when there is a closed system, a one-component system filled with water, a temperature of −22°C, and a container capable of withstanding the pressure. Only the temperature requirement is commonly fulfilled in nature. The disruptive force of ice in rock is thus generally not very great. A.C.B.

Identification of natural decolorizing clays by their mode of dehydration. C. L. ALEXANIAN. *Ann. Combustibles Liquides*, **11**, 471–86 (1936); *Chem. Abs.*, **30**, 6515 (1936).—Samples (1 g.) of clay, pulverized, sieved through 200-mesh, and dried 48 hr. at 40°, are suspended from the beam of a chainomatic balance into an electric furnace and are heated from 20° to 1100° at the same rate; the loss in weight (dehydration) is read every few minutes. Activated as well as unactivated clays belong to one of three types: (*a*) kaolinite, losing 10% sharply around 500°; (*b*) montmorillonite, losing 3% at 680°, and (*c*) common fuller's earth, which loses 2 to 3% slowly around 500°. The method is useful to obtain a preliminary indication of the probable commercial value of a sample of clay. Data are included covering several French and North African clays.

Krasnoufimsk fire clays. G. M. ERMOLIN. *Ogneupory*, **4**, 145–48 (1936); *Chem. Abs.*, **30**, 6905 (1936).—These clays contain 32.97 to 36.70% Al_2O_3. Their low sintering temperature (1100 to 1250°) and wide vitrification range make them suitable also for stoneware.

Natural and artificial plastic earths. W. PUKALL. *Sprechsaal*, **70** [30] 383–85; [31] 399–402 (1937).—(1) The use of plastic white and colored argillaceous materials in the chemical industry in a simple way at ordinary temperature and prevailing pressure is discussed. (2) Nepheline, not feldspar, is the mother rock of kaolin. (3) The process of formation of kaolin from nepheline-like materials is described. (4) The production of nepheline and its transformation into plastic bodies is discussed. (5) Argillaceous rocks, known but used little at present, were decomposed by means of a special method. (6) The plasticity of argillaceous raw materials is related to this decomposition. (7) A new simple method to purify natural raw materials is given; this method increases plasticity of the slightly plastic, crystalline, so-called paper-kaolin.

(8) The rôle of "natronite" in kaolins and clays is described. (9) A method for distinguishing kaolins and clays is given. (10) There is not much to say about the true composition of kaolin and the white plastic raw materials obtained, especially as to combined water of hydration. From the synthesis of nepheline and nepheline-like materials, it follows that they consist of at least two molecules of the so-called "kaolinic acid," and they correspond to the formula $4SiO_2 \cdot Al_2O_3$ which is a double compound of alumina and silica or their compounds. Kaolin is not a silicate, but an aluminate, like the feldspar or other groups. The kaolin formula, therefore, should read $2Al_2O_3 \cdot 4SiO_2 \cdot 4H_2O$ or $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$. M.V.C.

Nature and constitution of Yamagata bentonite: I. M. Utida. *Jour. Japan. Ceram. Assn.*, **44**, 603 (1936); *Trans. Ceram. Soc.*, **36** [3] 19A (1937).—The results of a study of the specific gravity, refractive index, and surface tension are reported.

Preparation of important ceramic raw materials. G. Herth. *Ber. Deut. Keram. Ges.*, **18** [2] 65–74 (1937).—G. discusses the preparation of various ceramic raw materials by the methods of picking and sorting, precipitation, washing apparatus, refining, air separation, flotation, magnetic separation, centrifuging, and elutriation, showing how the different methods are applied in preparing the different raw materials. E.J.V.

Production and commerce of diatomite in Great Britain. Anon. *Céramique*, **38**, 52 (1935); *Trans. Ceram. Soc.*, **34**, 79A (1935).

Researches on china clay. R. J. Davies, R. A. Green, and H. F. E. Donnelly. *Trans. Ceram. Soc.*, **36** [4] 173–200 (1937).—This investigation covered a study of the chemical and particle-size analyses, plasticity, transverse strength, drying and firing contraction, and porosity of six china clays. These clays ranged from a fat clay to lean clay with intermediate types, but because of the limited number it was considered unwise to generalize on the properties. It was found that the physical properties of the natural clays follow the malachite-green absorptions more closely than the actual particle-size analyses. This is explained on the basis of lack of data on particle distribution below 200$\mu\mu$ radius and also that no account has been taken of the presence of organic colloids as "humus." It was found, however, that the properties of the fired clays in general were affected by the particle size of the clays. R.A.H.

Soil humus: I, Estimate of soil humus by oxidation with alkaline permanganate. A. N. Puri and Anand Sarup. *Soil Sci.*, **44** [4] 323–27 (1937).—A method of estimating humus by oxidation with alkaline permanganate is outlined. The results obtained compare favorably with Wakley and Black's method of oxidation with chromic acid. A modification of Chakraborty's procedure for the destruction of organic matter for mechanical analysis is suggested. G.R.S.

Substitution of foreign paper kaolins. A. Laubenheimer. *Ber. Deut. Keram. Ges.*, **18** [3] 122–23 (1937).—To determine the feasibility of mixing paper clays, tests were made to ascertain the residue on a 100-mesh screen after mixing and the mineralogical constitution thereof; a grain-size distribution curve was set up, and the whiteness and plasticity were measured. Using 33 different kaolins, paper sheets were made, and the following properties were determined: (1) the number of scratches produced by the paper on a glass plate under a definite pressure, (2) the smoothness of the paper, determined by the resistance offered to an air current passing over the surface, (3) the whiteness of the paper, and (4) the yield, *i.e.*, the portion of kaolin which can be taken up from the paper mass. Tests along these lines permitted a classification of the kaolins in accordance with the grade of paper producible by their use. See *Ceram. Abs.*, **16** [7] 221 (1937). E.J.V.

Talc of Zaporozhskii deposits, Ukraine. A. E. Sidorenko. *Ogneupory*, **5** [4–5] 332–33 (1937).—Talc samples from these deposits showed an average composition of 56.26% SiO_2 and 27.32% MgO and a refractoriness of 1550°C. M.V.C.

Tektites. G. Baker. *Proc. Roy. Soc. Victoria*, **49** [2] 165–77 (1937).—In the Port Campbell district, 154 miles southwest of Melbourne, 135 australites (tektites) have been found. They are historically recent, one specimen in particular, a perfect glass button, having a new and fresh appearance. H.H.S.

Titanium. V. C. *Rev. Industrielle*, **67** [2338] 327 (1937).—Titanium and titanium-bearing minerals, their occurrence, and their chemical composition are discussed. R.W.D.

BOOKS AND BULLETINS

Annual report of the Nonmetals Division, fiscal year 1937. Oliver C. Ralston. *U. S. Bur. Mines Information Circ.*, No. 6974, 18 pp. Free. R. reviews the progress of the Nonmetals Division in studies on cracking of steel by boiler waters, kyanite concentration and preparation, spodumene concentration and lithium extraction, froth flotation and tremolite-talc mixtures, refractory properties of chromite, properties and uses of olivine, coal-washing methods, hydration of lime, size analysis of mineral powders, pozzuolanic minerals, quartz, and silica, fractionation of clays, concentration of feldspar ores, mica separation, and red iron ores. R.A.H.

Rutile in Brazil: occurrence, composition, and treatment. S. Fróes Abreu. *Ministerio Trabalho Ind. Com., Inst. Nacl. Tech.*, Separate, **1936**, 32 pp.; *Chem. Abs.*, **30**, 5909 (1936).—Conglomerates and diamantiferous sands of Goyaz yield a concentrate containing 95% TiO_2. Ores of Minas Geraes are derived from deposits resulting from disintegration of crystalline schists and pegmatites; these carry 70 to 85% TiO_2 along with Fe, owing to the presence of ilmenite. Experiments by A. show that electromagnetic separation succeeds best when the material is reduced to fineness between 0.2 and 0.15 mm.

Summary of Progress of the Geological Survey of Great Britain for 1936: I. H. M. Stationery Office, London, 1937. This annual summary of the work of the Geological Survey of Great Britain contains nothing extraordinary. It outlines the work done by the Survey as a whole and by the individual officers, mainly in remapping various districts. A.B.S.

Titanium on the coast of Espiritu Santo. S. Fróes Abreu. *Ministerio Agr. Estacao Exptl. Combustiveis Minerios*, Separate, **1933**, 64 pp.; *Chem. Abs.*, **30**, 5909 (1936).—Workable deposits of ilmenite occur almost ex-

clusively as beach sands in association with magnetite, monazite, zircon, and garnet. These sands are derived from archean granites and gneisses; the TiO_2 content of the sands may be as high as 43.6%. A concentrate containing 71.61% ilmenite, 6% monazite, and 12.96% zircon is obtained by water tables and magnetic separation.

Chemistry and Physics

Alkali aluminum silicates: VIII, Validity of Hüttig's equation for permutites. E. GRUNER. *Z. Anorg. Allgem. Chem.*, **221**, 142–48 (1934): *Chem. Abs.*, **29**, 5329 (1935).—Vapor-pressure isotherms for H, Na, and Ca permutites were determined from 69° to 184°. Hüttig's formula, $\log_e p = \log_e p_0 - (kn/n')$, is not valid for permutites without H_2O of hydration but gives values that are very high and not constant. If n' is diminished by a constant quantity representing those H_2O molecules that exercise a purely chemical function in the molecule, the expression becomes valid, and $k \cong 1$.

Analysis of Portland cement. P. N. GRIGOR'EV AND E. I. KOZHINA. *Zavodskaya Lab.*, **6**, 751–53 (1937). P.B. & E.S.

Analytical determination of aluminum oxide. YU. A. KLYACHKO AND E. E. GUREVICH. *Legkie Metally*, **3** [9] 24–28 (1935); abstracted in *Chem. Zentr.*, **1935, ii,** 560. —Al_2O_3 calcined at over 1000° is less hygroscopic and less soluble in various aqueous solutions (HCl, HNO_3, KOH, $CuCl_2$, $BiCl_3$, HCl + H_2O_2) than that calcined at lower temperatures. In general, the "wet" methods for determining Al_2O_3 are not recommended because solubility in various solutions must be taken into consideration in each separate case. M.V.C.

Boric acid and alkaline boric acid salts: VII, Comments on the constitution of perborates and polyborates. HEINRICH MENZEL. *Z. Anorg. Allgem. Chem.*, **219**, 35–41 (1934); *Chem. Abs.*, **28**, 7191 (1934).—M. discusses various theories on the structure of perboric acid, polyboric acid, and their salts.

Capillary condensation in an artificially produced capillary and determination of the thickness of the adsorbed water film on glass. K. V. CHMUTOV. *Zhur. Fiz. Khim.*, **9**, 345–49 (1937).—The phenomenon of condensation of water-vapor in an artificially made fissure (between two glasses closely pressed together) has been observed. The thickness of the water film has been calculated by the Thomson formula. P.B. & E.S.

Crystal and chemical studies of aluminum compounds with a spinel lattice and of γ-Fe_2O_3. Notes on mineralizing effect of fluorides. ERNST KORDES. *Z. Krist.*, **91**, 193–228 (1935); abstracted in *Chem. Zentr.*, **1935, ii,** 3637–38.—The synthesis of $LiAl_5O_8$ compounds of the spinel type, especially from melts containing fluorine, is described in detail. Spinel $LiAl_5O_8$ is easily derived from spinel $MgAl_2O_4$ by replacing 2Mg with LiAl. The properties of both spinels are similar. The presence of fluorides greatly promotes the formation of the spinel $LiAl_5O_8$ from the oxides. The significance and effect of fluorides as mineralizers on the synthesis of oxides, silicates, and aluminosilicates are discussed in detail. M.V.C.

Crystal plasticity: V, Completion of slip-velocity formula. E. OROWAN. *Z. Physik*, **98**, 382–87 (1935); *Chem. Abs.*, **30**, 2071 (1936).—A new term is added to the formula, so that it gives zero slip velocity for zero shearing stress; this term is practically negligible for metals but may be of importance in organic crystals.

Crystal structure of potassium, rubidium, cesium, and thallium fluosilicates and of $LiMnO_4 \cdot 3H_2O$. J. A. A. KETELAAR. *Z. Krist.*, **92**, 155–56 (1935); *Chem. Abs.*, **30**, 2821 (1936).—K_2SiF_6, Rb_2SiF_6, Cs_2SiF_6, and Tl_2SiF_6 are isomorphous with $(NH_4)_2SiF_6$ and have the K_2PtCl_6 type of structure. Unit-cell dimensions of the first 5 compounds are 8.168, 8.446, 8.867, 8.563, and 8.337 (all $\pm$ 0.007 Å), respectively; calculated densities are 2.668, 3.430, 3.859, 5.790, and 2.028, respectively; parameters are 0.215, 0.20, 0.19, 0.20, and 0.205, respectively. $LiMnO_4 \cdot 3H_2O$ is isomorphous with $LiClO_4 \cdot 3H_2O$ and the hexangonal cell has a = 7.78 and c = 5.39 (both $\pm$ 0.01 Å).

Density of aqueous boric acid solutions and the apparent molecular volume of boric acid in them. A. VON ENDRÉDY. *Z. Anorg. Allgem. Chem.*, **222**, 285–88 (1935); *Chem. Abs.*, **29**, 4241 (1935).—The density of solutions of H_3BO_3 ranging in concentration from 0.356 to 4.599% was determined at 16.9°, 20.0°, and 30.0°. Values of the expansion coefficient and apparent molecular volume were calculated. Between 0.1 mol. / liter and saturated solution, H_3BO_3 is almost an ideal nonelectrolyte.

Determination of fluorine in presence of amorphous silica. G. A. MARKOVA. *Zavodskaya Lab.*, **6**, 807–11 (1937).—The Villard-Winter method gives very reliable results in determinations of fluorine in phosphate minerals in the presence of amorphous silica. The admissible SiO_2:F ratio is much higher than that found in natural samples. The presence of Al_2O_3 in the material investigated hampers the quantitative separation of fluorine. The limit of the Al_2O_3:F ratio that does not influence the accuracy of determinations is sufficiently large (10:1). In the presence of both components investigated, an increase of the amount of the distillate is necessary. P.B. & E.S.

Determination of iron and manganese in silicates (slags, ores) from one sample. A. P. DUBINSKIĬ. *Zavodskaya Lab.*, **6**, 873–74 (1937).—The ferrous salt is first titrated by a potassium bichromate solution in the presence of diphenylamine; by adding sodium fluoride, potassium bichromate, and arsenious acid, bivalent manganese is oxidized to the trivalent form which is then titrated by a solution of ferrous sulfate in the presence of diphenylamine in a more acid medium than when titrating ferrous salts. The determination can be conducted in a medium of hydrochloric acid (with a reduction of $Fe^{...}$ to $Fe^{..}$ by tin chloride) or in a medium of sulfuric acid (with a reduction of $Fe^{...}$ to $Fe^{..}$ by metallic zinc or aluminium). The manganese content in the solution must not surpass 0.05 g.; otherwise, lower results are obtained. To obtain reliable results, if this quantity is higher, the sodium fluoride, cadmium bichromate, and arsenious acid content must be increased, which is not desirable. P.B. & E.S.

Determination of silica in silicate rocks. A. I. PONOMAREV. *Zavodskaya Lab.*, **6**, 691–93 (1937). P.B. & E.S.

Determination of silicon in cast iron, steel, and silicates. YU. YA. GORNYI. *Zavodskaya Lab.*, **6**, 541–44 (1937).—Silica is precipitated quantitatively from a solution in concentrated hydrochloric acid by shaking for 5 min. with gelatin (70 mg. for 50 ml. of solution for iron and steel and 300 mg. for 90 ml. of solution for silicates). The method makes possible a much quicker and more precise determination than by standard methods; the silica precipitate obtained contains fewer impurities. P.B. & E.S.

Effect of iron oxide on extraction of alumina from sinter and effect of iron oxide sol on stability of aluminate solutions. A. N. VARSHAVSKIĬ. *Legkie Metally*, **4** [4] 9–16 (1935); abstracted in *Chem. Zentr.*, **1936, I**, 134.—The yield of Al_2O_3 diminishes in a dry decomposition of bauxite with increasing Fe_2O_3 content when $Na_2O:Al_2O_3 \leq 1\%$. The question of how far the ratio $Na_2O:Al_2O_3$ can be increased to neutralize the effect of increased Fe_2O_3 content is being studied. M.V.C.

Effect of silicic acid on the magnetic properties of dissociated mixtures with iron oxide. W. LEITGEBEL AND K. BOCKEMÜHL. *Z. Anorg. Allgem. Chem.*, **225**, 209–12 (1935); *Chem. Abs.*, **30**, 1621 (1936).—Eleven mixtures of FeO, Fe_2O_3, and SiO_2 in varying proportions were heated to different temperatures from 1000° to 1560°, and the ratio $Fe_2O_3:Fe_3O_4$ in each of the end products was determined analytically. The temperature at which the magnetism disappeared was also determined. To a first approximation, the addition of SiO_2 produced little effect on the magnetic properties. The results are presented in both tabular and graphic form and are correlated with the work of White, Graham, and Hay on the dissociation of the Fe_2O_3–Fe_3O_4 system (*Ceram. Abs.*, **16** [4] 134 (1937)) and the magnetic investigations of Kleffner and Kohlmeyer.

Formation of barium aluminates from barium carbonate and alumina in solid state. G. GRUBE AND G. HEINTZ. *Z. Elektrochem.*, **41**, 797–804 (1935); *Chem. Abs.*, **30**, 977 (1936).—If pulverized mixtures of $BaCO_3$ and Al_2O_3 are heated in a CO_2 atmosphere in the temperature range between 900° and 1050°, monobarium aluminate is formed as the reaction product whether the starting mixture contains $BaCO_3$ or Al_2O_3 in excess. Aluminates in which more than 1 mol. Al_2O_3 is united to 1 mol. BaO do not form under these conditions. At temperatures from 1000° upward, reaction products are formed in which the Al_2O_3 is bound entirely as aluminate and the $BaCO_3$ is practically entirely transformed into BaO. Extensive measurements were made of the equilibrium pressures of the reactions to determine whether dibarium or tribarium aluminates are formed. E.J.V.

Heat of reaction of calcium hydroxide with kaolin, aluminium hydroxide, and silica fired at different temperatures. P. P. BUDNIKOV AND L. G. GULINOVA. *Kolloid. Zhur.*, **3** [3] 195–207 (1937).—The authors criticize different opinions on the nature of dehydration and transformation of kaolin. For their investigations they used a washed kaolin to which they ascribe the formula $H_2Al_2Si_2O_8 \cdot H_2O$. The kaolin was fired at different temperatures between 500° and 1150°C for 1 hr. and quickly cooled. The product obtained was finely ground and screened through a 10,000-mesh/cm.^{2} screen without residue. Colloidal silica and aluminium hydroxide were prepared separately and fired under the same conditions at the above temperatures. For the investigations a diphenylmethane calorimeter was used in which the heat of interaction of $Ca(OH)_2$ and fired kaolin, silica, and aluminium hydroxide in a water medium was determined. The investigations showed that the amount of heat evolved depends on the firing temperature. The highest activity of the kaolin investigated after firing is at about 800°C (in 11 hr., 11.9 g./cal. were evolved). Metakaolinite combines with $Ca(OH)_2$, forming calcium aluminosilicate of the zeolite type; the products of decomposition of metakaolinite obtained after firing at over 1000° do not have the faculty of combining with $Ca(OH)_2$ ("Investigation—," *Ceram. Abs.*, **15** [3] 107 (1936)). Aluminium hydroxide, $Al_2O_3[Al(OH)_3]$, retains its activity up to the firing temperature 800° (20.21 g./cal. were evolved in 1 hr.); then its activity falls and at 1000° ceases. Heat is evolved because of the formation of hydrocalcium compounds. Colloidal SiO_2 retains its activity up to the ignition temperature of 600°C (35.25 g./cal. were evolved in 1 hr. and 20 min.), after which the activity falls abruptly. The evolution of heat takes place because of the formation of $CaO \cdot SiO_2$ aq. For determining the activity of these materials, the authors used the method of electrical conductivity. Finely ground kaolin fired at different temperatures, collodial SiO_2, and aluminium hydroxide were placed in a closed container, into which were introduced 100 cc. of a transparent saturated $Ca(OH)_2$ solution. The electrical conductivity, λ $Ca(OH)_2$, of lime was equal to 870×10^{-6}. Into the same container were introduced 5 g. of the material investigated. The authors made conclusions on the activity of the materials investigated by the fall of electrical conductivity. This method confirmed the calorimetric investigation data. See *ibid.*, **16** [1] 7 (1937); "Relation—," *ibid.*, **17** [1] 22 (1938). P.B. & E.S.

Influence of chemical binding on the $K\alpha_{1,2}$ doublet of silicon. N. G. JOHNSON. *Z. Physik*, **95**, 93–96 (1935); *Chem. Abs.*, **29**, 6837 (1935).—Wave-length measurements are made for the doublet with Si, SiO_2, $SiO_2 \cdot nH_2O$, K_2SiO_3, K_2SiF_6, and SiC. The doublet is displaced to the shorter wave-length in the compounds compared with the position in the free element. The O-containing compounds show the same displacement, 2.4 Å. K_2SiF_6 gives a displacement of 3.8 Å. This is due to the 6 F atoms.

Method for detecting small amounts of niobium and tantalum in minerals, rocks, and metals. J. P. ALIMARIN AND B. J. FRIED. *Mikrochemie*, **23** [1] 17–23 (1937).—These elements form white, almost insoluble precipitates in strong tartaric acid solutions with phenylarsenious acid. The reaction is somewhat disturbed by the presence of appreciable amounts of tin, zirconium, and titanium. The last two elements may be separated beforehand with pyrogallic acid. The sensitiveness of the reaction is $2\gamma(Nb,Ta)O_5/cm^3$. L.E.T.

Microanalytical methods. NORMAN STRAFFORD. *Chem. Age*, **34**, 218–19 (March 7, 1936). H.H.S.

Molecular state of oxides dissolved in cryolite. V. P. MASHOVETZ. *Zhur. Priklad. Khim.*, **9**, 802–805 (in English, 805–806) (1936).—Calcium oxide dissolved in melted cryolite is in equilibrium with the products of its interaction with cryolite, CaF_2, Al_2O_3, and NaF. The same is true for sodium oxide in $NaAlO_2$ and its products of interaction with cryolite, Al_2O_3, and NaF. Aluminium oxide and cryolite

are in equilibrium with sodium aluminate and aluminium fluoride. If CaO and Na_2O are both introduced in an electrolyte cell, they partly decompose the AlF_3 of cryolite which must be compensated by an addition of AlF_3. The presence of aluminates in the electrolyte can be explained by the existence of an AlO_3 anion. The X-ray determination of the crystal structure of Al_2O_3 suggests alumina to be an aluminium aluminate, $Al(AlO_2)_3$, forming by dissociation the AlO_2 anion. P.B. & E.S.

Ortho salts of oxygen acids. E. Zintl, W. Morawietz, and G. Woltersdorff. *Naturwissenschaften*, **23**, 197 (1935); *Chem. Abs.*, **29**, 4983 (1935).—Na_2O can unite with many salts of simple O acids to give complex anions of ortho salts and polybasic acids: Na_3NO_4 from $NaNO_2$ and Na_3NO_5 from $NaNO_3$. Such salts are unstable toward H_2O or CO_2 and can not be made with NaOH or Na_2CO_3. Na_2O likewise reacts with weakly acid metal oxides to ortho salts: Na_4ZnO_4, Na_4CuO_3, Na_2NiO_2. The coordination number of the central metal atom increases with its size (Na_2CO_3 *vs.* Na_4SiO_4 and Na_4SnO_4 *vs.* Na_3PbO_4). In the first series of the periodic system this number at first decreases from Be (4) to B (3), and C (3) then increases for N to 4. This is due to compensating effects (electrostatic) of increasing charge and decreasing size. The ortho salts were identified by X-ray analysis.

Phosphate method for the determination of magnesium. P. S. Savchenko. *Zhur. Priklad. Khim.*, **9**, 2069–74 (in German 2074) (1936).—A weighted sample of $MgSO_4$ was dissolved in 100 to 150 ml. of water, and 1 g. sodium and ammonium phosphate, 1 g. ammonium chloride, and 0.5 to 1 ml. of HCl were added; after heating to 60°, ammonia of a concentration of 1 to 2 ml. in 30 ml. of water was added for precipitation. After precipitation, up to 50 ml. for 250 ml. of the total solution of concentrated ammonia were added. In this method, a quick and full precipitation of magnesium and ammonium phosphate was reached at different concentrations. For some technical purposes the calcination of the precipitate can be omitted.

P.B. & E.S.

Rare earths: II. J. S. Štěrba-Böhm and M. Melichar. *Collections Czechoslov. Chem. Commun.*, **7**, 131–45 (1935); *Chem. Abs.*, **29**, 4279 (1935).—From the chemical viewpoint Sc is not a true rare earth, but resembles Al in its amphoteric nature. The degree of hydrolysis of $Sc(AcO)_3$, determined by extraction with Et_2O, is 9.36, 17.14, and 19.22% in 0.414, 0.02, and 0.002 *N* solution, respectively, while that of $Y(AcO)_3$ and $La(AcO)_3$ in 0.1 *N* solution is 0.71% and 0.31%, respectively. Electrometric titration of $Sc(AcO)_3$ first gives a precipitate at p_H 6.10 after addition of 2.25 equivalents of KOH, in contrast to the more basic character of other rare earths. Addition of freshly prepared $Sc(OH)_3$ or $Sc(HCO_3)_3$ to boiling, concentrated KOH, followed by vacuum crystallization, filtration, and washing with alcohol, gives very hygroscopic crystals of $K_3[Sc(OH)_3 \cdot H_2O] \cdot 3H_2O$. This, washed with H_2O, yields crystalline $2Sc(OH)_3 \cdot H_2O$. Addition of $Y(AcO)_3$ to boiling KOH gives crystalline $Y(OH)_3$, indicating temporary solution as K yttriate, whereas $La(AcO)_3$ gives only amorphous $La(OH)_3$. A description and 8 photographs of these crystalline compounds are given.

Rationalization of analysis of silicate minerals and rocks. P. I. Vasil'ev. *Mineral. Syr'e*, **11** [4] 56–69 (1936); *Chem. Abs.*, **30**, 5907 (1936).—Laboratory organization and known procedures of analysis are discussed, with 20 references.

Reaction velocity of silicates in powdered mixtures in consequence of dissociation of metallic oxides and crystallographic changes of quartz. J. A. Hedvall and G. Schiller. *Z. Anorg. Allgem. Chem.*, **221**, 97–102 (1934); *Jour. Soc. Glass Tech.*, **19** [76] A333 (1935).—Mixtures of CuO, ZnO, NiO, and Co_3O_4 were heated with Scheering-Kahlbaum SiO_2 at temperatures up to 1000°, and the proportion of reacted material was determined. At 575° (the β–α quartz change) there was a slight increase in the reaction velocity, and at 870° (the α–quartz–cristobalite change) a marked increase. The reacted Co_3O_4 was 2.5% at 800° but reached 19% at approximately 900°. An analysis of the Kahlbaum SiO_2 is not given.

Reactions between sodium carbonate and ferric oxide and alumina. V. A. Mazel and S. N. Astanovitzkaya. *Legkie Metally*, **5** [4] 12–18 (1936); *Chem. Abs.*, **30**, 7053 (1936).—Na_2CO_3 begins to react with Fe_2O_3 and with Al_2O_3 at 500°. The reactions are rapid at 700°. An excess of Na_2CO_3 increases the speed of reaction below 900° but at higher temperature decreases it. In all cases, $Na_2O \cdot Fe_2O_3$ and $Na_2O \cdot Al_2O_3$ are the only compounds produced.

Separation of selenium from cadmium, lead, bismuth, antimony, molybdenum, tungsten, and vanadium. V. Hovorka. *Collection Czechoslov. Chem. Commun.*, **7**, 182–97 (1935); abstracted in *Chem. Zentr.*, **1936**, ii, 119.

M.V.C.

Solubility of various oxides in cryolite. E. I. Kazanov. *Legkie Metally*, **5** [12] 16–21 (1936); abstracted in *Chimie & Industrie*, **38** [3] 496 (1937).—From the viewpoint of dissolving in cryolite, various oxides can be classified as (1) oxides of light metals dissolving rapidly in fused cryolite and (2) oxides of heavy metals which dissolve only very slowly and slightly. This low solubility of oxides of heavy metals can be used for direct electrolysis of aluminous minerals (bauxite, kaolin, etc.). M.V.C.

Structures and forces in colloidal systems. H. Freundlich. *Proc. Roy. Inst. Gt. Brit.*, **29**, 232 (1936); *Trans. Ceram. Soc.*, **36** [2] 18A (1937).—F. gives the history and structure of colloids generally, and the term "thixotropy" is defined as "isothermal reversible sol-gel formation." Consideration is given to (1) the structure and forces concerned in thixotropic materials, particularly grain size, (2) the distinction between thixotropy and coagulation, and (3) its function as the counterpart of dilatancy. Plasticity, like thixotropy, is linked up with close packing Simple popular examples are given.

Symbols of thermodynamical and physicochemical quantities and conventions relating to their use. Joint Committee of the Chemical Society, the Faraday Society, and the Physical Society. *Chem. & Ind.*, **59** [39] 860–65 (1937).—The objects of the committee were (1) to correlate the views of chemists and physicists on the use of symbols for quantities employed in thermodynamics and to eliminate as far as possible the confusion that has arisen through the diversity of usage in this field, and (2) to deal summarily with symbols for other quantities which are of interest to both chemists and physicists. Lists of recommended symbols and conventions are given. G.R.S.

System alkali oxide–CaO–Al_2O_3–SiO_2–CO_2: V, Stable equilibria in the system Na_2O–SiO_2–CO_2 and pressures of CO_2 in the reaction between K_2CO_3 and K_2SiO_3. C. KRÖGER AND E. FINGAS. *Z. Anorg. Allgem. Chem.*, **225**, 1–23 (1935); *Jour. Soc. Glass Tech.*, **20** [77] A256 (1936).—The reaction of Na_2CO_3 with $Na_2Si_2O_5$, $Na_2Si_2O_7$, $Na_6Si_2O_7$, and mixtures of these materials was investigated by measuring the pressure of CO_2 over the mixtures heated at various temperatures. CO_2 was absorbed only when the ratio $Na_2O/SiO_2 > 0.05$. Decomposition pressure-temperature diagrams are given for this system and for the system K_2O–SiO_2–CO_2. For Part III see *Ceram. Abs.*, **15** [3] 108 (1936).

Technical applications of polarized light. H. VIGNERON. *Nature* [Paris], No. 5, pp. 245–46 (1937).—V. reviews the classical means used for polarizing light, *viz.*, Nicol prism, Malus polariscope, birefringent and dichroic substances (tourmaline), and gives, as an important application of polarized light, the determination (by means of glass or transparent celluloid reductions) of stresses or strains that develop in the different members of structural steel frameworks. In 1851, W. H. Herapath discovered the dichroism and birefringence of quinine iodosulfate, and in 1932 E. A. Land succeeded in manufacturing a technical light-polarizing material by incorporating herapathite into celluloid and subsequently rolling the mixture into large transparent sheets. The most important application of this new material is its use for suppressing the glare caused by light projectors. Explanations for the use of the material are given. R.W.D.

Theory of photoelasticity. HANS MUELLER. *Jour. Amer. Ceram. Soc.*, **21** [1] 27–33 (1938).

Trivalent and quadrivalent manganese. J. H. KŘEPELKA AND J. KUBIS. *Collections Czechoslov. Chem. Commun.*, **7**, 105–24 (1935); *Chem. Abs.*, **29**, 4279 (1935).—MnO_2 in dry Et_2O treated with dry HCl at −63° and −78° yields green and brown solutions containing $MnCl_4$. Addition of CCl_4 or ligroin precipitates solid, black, unstable $MnCl_3$ (soluble in Et_2O with a violet color) and no $MnCl_4$, contrary to the results of Holmes. With CCl_4 or ligroin as the reaction medium, only $MnCl_3$ is obtained.

$2CaO·Al_2O_3$ a chemical compound? S. KONDO AND T. YAMAUCHI. *Jour. Japan. Ceram. Assn.*, **43**, 495 (1935); *Trans. Ceram. Soc.*, **34**, 93A (1935).—The results of chemical, optical, and X-ray examinations of fusions of various mixtures of C.P. calcium carbonate and alumina indicate that dicalcium aluminate is merely a mixture of $3CaO·Al_2O_3$ and $5CaO·3Al_2O_3$.

Two intermetallic compounds of beryllium with iron. L. MISCH. *Naturwissenschaften*, **23**, 287–88 (May 3, 1935); *Metals & Alloys*, **6** [12] MA505 (1935).—A compound, $FeBe_2$, whose structure is hexagonal and similar to that of $MgZn_2$, was found in the Fe–Be system. There are 12 atoms per unit cell. The lattice constants are $a = 4.212$Å and $c = 6.834$Å. The density is 4.65 g./cc. The parameters of the lattice point positions are $u = 0.833$ and $v = 0.063$. This phase has a ferromagnetic transformation at 521° to 524°C. The direction of strongest magnetism lies in the hexagonal base plane. Another compound, $FeBe_5$, was found which is not ferromagnetic at ordinary temperatures, but is attracted by an electromagnet at liquid air temperatures. The structure is face-centered cubic and similar to $MgCu_2$, with 24 atoms per unit cell. The 8-point positions of the Mg atoms are occupied statistically by 4 Fe and 4 Be atoms. The lattice constant is 5.878Å.

Virial theorem and the theory of fusion. E. L. HILL. *Physik. Z. Sowjetunion*, **8**, 401–406 (1935); *Chem. Abs.*, **30**, 2068 (1936).—The force function commonly used to describe the mutual interactions between molecules is discussed, and it is emphasized that this function contains a contribution from the kinetic-energy terms of the electrons. From this fact, with further simplifying assumptions about the process of melting, a schematic explanation of the observed changes in kinetic and potential energies of the molecules along the melting curve is proposed.

Volumetric method for determining aluminum in aluminate solutions. M. K. BAKHMUTOVA. *Legkie Metally*, **3** [9] 37–41 (1935); abstracted in *Chem. Zentr.*, **1935, ii**, 560.—The method is based on the determination of the total acidity and of the free acid; from the difference between these values, the amount of acid combined with Al is obtained. M.V.C.

X-ray determination of the structure of liquids and g[illegible]s. B. E. WARREN. *Jour. Applied Physics*, **8** [10] 645–55 (1937).—W. presents a general discussion of X-ray analysis and deductions from the diffraction patterns of vitreous silica, liquid sodium, and water regarding the distinction between the vitreous and the crystalline states. A.P.

Yellow cuprous oxide. M. STRAUMANIS AND A. CIRULIS. *Z. Anorg. Allgem. Chem.*, **224**, 107–12 (1935); *Chem. Abs.*, **30**, 2870 (1936).—Samples of cuprous oxide ranging in color from yellow to violet-red were prepared by various methods. They were studied, both dry and in aqueous suspension, by means of Debye-Scherrer diagrams. All preparations gave the same lattice constant, 4.256 ± 0.002 Å, which is in good agreement with the established value for Cu_2O, 4.252 ± 0.002 Å. They therefore have the same structure. The difference between the yellow and the red preparation was not in the sequence of the interference lines but in the number and width of the lines. The sharpness and number of lines increased as the products became redder. Heating yellow preparations increased the number of lines. The lighter colored, yellower preparations of Cu_2O, therefore, have a smaller particle size than the redder ones.

PATENTS

Coherent porous zirconium silicates. C. J. KINZIE (Titanium Alloy Mfg. Co.). U. S. 2,101,947, Dec. 14, 1937(July 29, 1933). The method of making porous zirconium silicates comprises mixing natural zircon grains with an aqueous solution of a zirconium and silicon containing salt, adding an ammonia vapor to aid in setting the mixture, shaping the mixture to form, and then firing it at temperatures between 800° and 1500°C.

Making alkali subsilicates. R. L. DAVIES (Pennsylvania Salt Mfg. Co.). U. S. 2,100,944, Nov. 30, 1937 (Sept. 3, 1936). The process of preparing a solid alkali subsilicate product comprises adding molten caustic alkali, containing not more than approximately 15% water, and a solid, sub-divided, silica containing material selected from the group consisting of silica and alkali metal silicate having a molecular ratio of SiO_2 to alkali oxide greater than 1:1, to a reaction vessel, the reactants being present in such

molecular proportions that the alkali oxide content is not less than the silicon dioxide content, reacting the mixture while stirring it at a temperature below the melting point of the reaction product sufficient to form an alkali subsilicate product, and converting the reaction mass into a solid state.

Process and apparatus for the manufacture of oxides or suboxides of lead. J. AITKEN. Brit. 474,267, Nov. 10, 1937 (July 13, 1936).

Production of magnesium from magnesium oxides. ADOLF VOGT (Alexander Wacker Gesellschaft für Elektrochemische Industrie, G.m.b.H.). U. S. 2,099,151, Nov. 16, 1937 (April 3, 1936). A process for reducing magnesium oxide comprises melting the magnesium oxide in a vacuum of about 10 to 40 mm. of mercury with a reducing agent forming oxides less volatile than magnesium in the presence of sufficient flux to liquefy the mixture.

Production of sodium polysilicates. W. H. A. THIEMANN (I. G. Farbenindustrie A.-G.). Brit. 474,729, Nov. 17, 1937 (April 16, 1937).

General

Characteristic properties of certain industrial dusts. H. V. A. BRISCOE, JANET W. MATTHEWS, P. F. HOLT, AND PHYLLIS M. SANDERSON. *Bull. Inst. Mining & Met.*, No. 391, 11 pp.; No. 394, pp. 3–31; No. 396, pp. 1–4 (1937); *Jour. Chem. Met. Mining Soc. S. Africa*, **37**, 533–39 (1937).—Samples from naphthalene filters are better for petrographic examination than salicylic acid residues. The fine dust from drilling takes relatively large amounts of H_2O into firm combination. From a rock with 0.6% ignition loss, the dust collected 10, 20, and 40 ft. from the face showed 3.7, 5.7, and 8.4% ignition loss, respectively, increasing with fineness of dust. This is accompanied by loss of alkali in proportion to hydration. Fine asbestos dust was alkaline, and the finer the dust, the greater was alkali extraction by H_2O. A crystal of asbestos laid on neutral agar jelly containing phenolphthalein showed a strong alkaline reaction (p_H 10 to 11) at the broken ends of the crystal but not along its sides. Alkali loss was accompanied by loss of SiO_2, much greater per unit weight of dust than normal solubility of SiO_2. Fresh dusts are more reactive than dusts after exposure to air. Solubility of siliceous dusts is greatly influenced by the presence of extraneous substances. The relationship of alkali and soluble SiO_2 release is obscure. *Bull. Inst. Mining & Met.*, No. 393, 12 pp.; No. 394, pp. 3–31 (1937); *Jour. Chem. Met. Mining Soc. S. Africa*, **38**, 42–48 (1937). Dust samples (1 g.) were extracted for 5 hr. at 100° with 100 cc. of H_2O. Amounts of SiO_2 dissolved were as follows: for asbestos 25.2, pure flint 24.0, calcined flint 5.7, quartz 5.2, feldspar 3.4, sericite 2.2, and kaolin 0.8 mg. Extraction of SiO_2 from cement and sillimanite, considered comparatively harmless, is of a much lower order of magnitude than that from flint or asbestos. An equal weight of lime or cement greatly reduced SiO_2 extraction from asbestos (0.3 mg. SiO_2 using CaO) and from calcined flint. Ca borate had a lesser depressing effect on extraction of asbestos, Ca citrate and Ca lactate only a slight effect, and $CaCO_3$ none. Extraction of SiO_2 from quartz is completely prevented by CaO but $CaCO_3$ and NaCl have no effect. MgO gives results similar to CaO, but $MgCO_3$, Al_2O_3, and ZnO are without effect. Sugar C markedly depresses the yield of soluble SiO_2 from quartz, 90% in one case, but does not affect extraction of asbestos, flint, orthoclase, or kaolin. Cryolite decreases the yield from flint and asbestos but increases SiO_2 extraction from kaolin, feldspar, cement, and quartz. NaF seems to act like cryolite. Extraction of calcined flint samples from various sections of the "labyrinth" shows constant CaO extraction from all sizes but a progressive increase in SiO_2 extraction (300%) with decrease in dust size down to about 1μ, after which it is constant; chemical analyses of the dust were substantially the same. See *Ceram. Abs.*, **16** [10] 315 (1937). A.H.E.

Dust content of the silicotic lung of an earthenware worker. N. SUNDIUS, A. BYGDEN, AND T. BRUCE. *Ber. Deut. Keram. Ges.*, **17** [2] 73–90 (1936); see "Mineral—," *Ceram. Abs.*, **16** [1] 49 (1937). E.J.V.

Economic organization in the ceramic industry. EICKE. *Sprechsaal*, **70** [32] 412–14; [33] 421–23 (1937).—By means of organization measures and continuous observation, it is possible to increase efficiency in ceramic plants and works. M.V.C.

Geochemistry applied to the problems of silicosis. A. BRAMMALL AND J. G. C. LEECH. *Bull. Inst. Mining & Met.*, No. 393, 9 pp.; No. 394, pp. 3–31 (1937); *Jour. Chem. Met. Mining Soc. S. Africa*, **38**, 22–26 (1937).—SiO_2, Al_2O_3, Fe_2O_3, and sericite, familiar residuals in geochemistry, characterize accumulations in silicotic lungs. Weathering of rocks alters all but the most refractory to a clayey, ferruginous, siliceous, or micaceous residuum by hydrolysis, oxidation, and leaching of bases, chiefly by CO_2 solutions. The biochemical environment in the lungs, in which CO_2 is emanational, would lead to hydrolysis and selective leaching of bases such as Na_2O, K_2O, CaO, and MgO, which form readily soluble carbonates or bicarbonates, and leave refractory residuals such as Al_2O_3, Fe_2O_3, and SiO_2. A possible intermediate product is sericite. Finely divided biotite was leached for 4 hr. at room temperature with 0.2 *N* KCl solution. Of the initial F, 78% was extracted and replaced by hydroxyl. Hydrolysis entailed a net increase of 23% in combined H_2O. The main constituents extracted were bases: CaO 26, MgO 51, and Fe_2O_3 53%. Al_2O_3 loss was only 2%. The residue was a true biotite that had advanced only a short step toward the composition of the ultimate residuum typical of the mineral matter found in silicotic lungs. Similar extraction of hydromuscovite (sericite) showed that even cold KCl solution hydrolized and leached a mica similar to sericite, but hot NaCl solution is more effective. Combined H_2O increased 39%. Soluble SiO_2 loss was 15.5%, soluble Al_2O_3 4.3%, alkalis 9%, and appreciable amounts of CaO, Fe oxides, and MgO. A.H.E.

Hydrolysis of rock-forming minerals. A. BRAMMALL AND J. G. C. LEECH. *Bull. Inst. Mining & Met.*, No. 391, 3 pp.; No. 394, pp. 3–31 (1937); *Jour. Chem. Met. Mining Soc. S. Africa*, **37**, 539–40 (1937).—When moistened with cold H_2O, the following mineral dusts are partially dissociated, the H_2O then giving an alkaline reaction: biotites and other basic micas; hornblendes and other amphiboles in-

cluding asbestos; wollastonite, diopside, hypersthene, augite, aegirite, and other pyroxenes; olivine, apatite, sphene, and some varieties of tourmaline; grossularite, melanite, and some varieties of almandite; members of the chlorite and epidote groups; calcite, aragonite, magnesite, and dolomite; and brucite and chondrodite. Sericite, hydromuscovite, and true muscovite are among the less readily reactive species. Clay is erratic. Sericite, hydromuscovite, muscovite, and the basic micas yield Al_2O_3 on treatment with weak (less than 0.2 *N*) solutions of salines; extraction is accelerated with heat. See *Ceram. Abs.*, **16** [10] 309 (1937). A.H.E.

Hygroscopic properties of ceramic bodies. A. A. Shumilin. *Ogneupory*, **4**, 701–708 (1936); abstracted in *Chem. Zentr.*, **1937, i**, 4674.—It is generally assumed that all ceramic materials are hygroscopic. Pure clays are more hygroscopic than those mixed with grog; fat clays are more hygroscopic than lean clays; grog alone is practically nonhygroscopic. The humidity content of a mixture of clay and grog can be computed from the clay content of the mixture and the moisture content of pure clay "in equilibrium." When drying ceramic bodies, the hygroscopicity of the material to be dried should be taken into consideration. M.V.C.

Industrial dermatoses—treatment and legal aspects—review of recent literature. J. G. Downing. *Jour. Ind. Hyg. & Toxicol.*, **17** [4] 138–65 (1935).—D. classifies the eruptions according to the type of irritant causing them. E. J. V.

Physics of air hygiene. H. B. Meller and F. F. Rupert. *Jour. Applied Physics*, **8** [7] 473–79 (1937).—Pollution of the air in cities and industrial plants has become increasingly obnoxious and harmful. Prevention of atmospheric contamination must take place at the major source, factories. Methods for determining atmospheric impurities and for smoke and dust abatement are described briefly. A.P.

Porous solid filters for sampling industrial dusts. Janet W. Matthews, P. F. Holt, Phyllis M. Sanderson, and H. V. A. Briscoe. *Bull. Inst. Mining & Met.*, No. 386, 9 pp.; No. 387, pp. 1–31 (1936); No. 388, pp. 1–15; No. 391, pp. 23–25; No. 393, p. 13 (1937); *Jour. Chem. Met. Mining Soc. S. Africa*, **37**, 161–66 (1936); 324–42, 356–57 (1937).—Methods of preparing and using filters of pure, finely crystallized, salicylic acid carried on a suitable support, preferably stainless steel gauze, are described. A.H.E.

Sampling of industrial dusts by means of the "labyrinth." H. V. A. Briscoe, Janet W. Matthews, P. F. Holt, and Phyllis M. Sanderson. *Bull. Inst. Mining & Met.*, No. 393, 21 pp.; No. 394, pp. 3–31 (1937); *Jour. Chem. Met. Mining Soc. S. Africa*, **38**, 27–41 (1937).—To collect larger dust samples than possible in the salicylic acid filter and to avoid the necessity for dissolving any filtering medium, a labyrinth 36 in. long and 3 in. inside diameter, containing 32 Cu baffles, was designed. Most of the dust is collected in the first 3 or 4 chambers. A smooth mass-distribution curve is obtained for most samples; extrapolated to zero dust content, efficiencies of 90 to 95% are indicated by comparison of the area under the determined curve with that under the extrapolated curve. Low rates of air flow lower efficiencies. Most of the dust is thrown out centrifugally from stationary eddies. A.H.E.

Science, invention, and society. Waldemar Kaempffert. *Jour. Applied Physics*, **8** [7] 449–55 (1937).—The trend of society in the era of scientific investigation and mechanical invention increasingly demands that leadership be assumed by scientific experts. A.P.

Science and practice in heavy ceramics. Fritz Kästner. *Ber. Deut. Keram. Ges.*, **18** [3] 123–24 (1937).—K. points out that while there is always a desire to make greater use of domestic raw materials and to replace imported materials in the production of heavy ceramic ware, such as refractories, the plants are often operated by practical men who disregard or do not apply findings of scientific investigators. By proper application of scientific knowledge it is possible to make better use of domestic crude materials and to replace imported materials. E.J.V.

Semi-works of E. I. du Pont de Nemours & Co. C. J. Darlington. *Ind. Eng. Chem.*, **27**, 863–66 (1935); *Chem. Abs.*, **29**, 5945 (1935).

Silicosis risks in china factories. Anon. *Pottery & Glass Record*, **19** [11] 283 (1937).—C. L. Sutherland, A. Meiklejohn, and F. N. R. Price, who have been working for several years on the causes of silicosis in pottery manufacture, report that an adequate substitute for flint has been found in calcined alumina. A special medical investigation has shown that there is no pneumoconiosis or other pulmonary disease caused by alumina dust used for placing ware in potteries. A.B.S.

Silicosis in sandblasters: examination of sands associated with sandblasting. Frank S. Fowweather. *Jour. Hyg.*, **36**, 67–73 (1936); *Chem. Abs.*, **30**, 3905 (1936).—In sandblasting, the sand is rapidly ground into a fine siliceous dust, whether used as the abrasive agent or introduced on the articles treated. The use of steel shot does not decrease the hazard if any sand is present. At least some of the dust is of a micaceous nature, in the form of sericite or a similar mineral. In spite of the opposite view, free silica dust is the major factor of sandblaster's silicosis.

Smoke and dust removal from air. G. W. Penney. *Ind. Heating*, **4** [8] 663–73 (1937).—P. describes a new method of electrostatic precipitation which can be operated at lower voltages than the usual electric apparatus. Besides being employed in air conditioning, dust removal, and the recovery of ore and metal dusts, it is being used for the reclamation of fine glazes in a chinaware decorating plant and for the removal of porcelain spray from the spray-booth exhaust in porcelain enameling plants. See "Electrical—," *Ceram. Abs.*, **16** [5] 156 (1937). M.H.

System for obtaining, from mine air, dust samples for physical, chemical, and petrological examination. H. H. Watson. *Bull. Inst. Mining & Met.*, No. 386, 33 pp. (1936); No. 388, pp. 1–15; No. 390, pp. 41–47; No. 391, pp. 23–25; No. 393, p. 13 (1937); *Jour. Chem. Met. Mining Soc. S. Africa*, **37**, 166–96 (1936); 324–42, 356–57, 485–89 (1937).—Instructions for using salicylic acid filters and the thermal precipitator are given. See "Physical—," *Ceram. Abs.*, **15** [6] 195 (1936). A.H.E.

Wells, a pioneer potter. J. M. Wells. *Bull. Amer. Ceram. Soc.*, **16** [12] 490 (1937).

What TVA is doing in ceramic research. R. E. Gould.

Chem. & Met. Eng., **44** [6] 320 (1937); see *Jour. Amer. Ceram. Soc.*, **20** [6] 175–214 (1937). M.C.S.

BOOKS AND BULLETINS

Ceramic Industrial Materials. FELIX SINGER. Reprint from the Handbook of Chemical-Technical Apparatus, Mechanical Aids, and Industrial Materials, pp. 784–858, edited by A. J. Kieser, Berlin, 1937. The book is divided into 4 parts. In Part I the ceramic ware of industrial importance is classified on the basis of porosity and refractoriness into (1) earthenware, (2) sinter ware, (3) stoneware, (4) porcelain, (5) steatite ware, and (6) refractory oxides. The characteristic properties of each are mentioned. In Part II values are tabulated for the following important physical properties: chemical resistance to alkalis and acids; compressive, tensile, and impact strengths; elasticity moduli; wear resistance; melting temperatures: refractoriness under load; thermal expansivities; heat conductivities; porosities and apparent densities; dielectric constants. The refractory sinters Al_2O_3, BeO, ZrO_2, ThO_2, Zr_2SiO_4, and siemensite (a spinel of MgO, Al_2O_3, and Cr_2O_3) are described in more detail. Part III describes the application of particular types of material. Part IV describes and illustrates various forms of apparatus made of ceramic ware: furnaces and kilns for the production of acids and alkalis, washing and absorption towers, valves, vacuum and pressure vessels, stills, exhaust fans, stirrers, mills, presses, centrifuges, etc. H. INSLEY

Classification and selection of Illinois coals. G. H. CADY. *Illinois State Geol. Survey Bull.*, No. 62; reviewed in *Power*, **79** [12] 669 (1935).—The method of selection based on the system of classification recently adopted for North American coals by the A.S.T.M. is presented. C. gives a compilation of analyses of face samples of Illinois coals with mine and county averages and reproductions of three monographs for determining the heat value of "coal as received," based on values from tables. F.G.H.

Engineer's Year-Book of Formulas, Rules, Tables, Data, and Memoranda for 1937: a Compendium of the Modern Practice of Civil, Mechanical, Electrical, Marine, Gas, Aero, Mine, and Metallurgical Engineering. Compiled by H. R. KEMPE AND W. HANNEFORD-SMITH. 43d annual ed. Revised under direction of L. St. L. Pendred. Morgan Bros., Ltd., London, 1937. lxi + xiv + 2676 pp. Price 31s 6d net. Reviewed in *Nature*, **139** [3526] 906 (1937).—Sections on machine tools, metallurgy, aeronautics, paints, and varnishes have been revised. The descriptive sections contain particulars of various products of numerous engineering firms. J.L.G.

Mining and grinding methods and costs at the Malvern Clay Co. mine, Malvern, Ohio. E. J. LINTNER. *U. S. Bur. Mines Information Circ.*, No. 6962, 22 pp. Free. R.A.H.

Protection of Labor in the Glass Industry (Arbeitsschutz in der Glasindustrie). W. GUTMANN. Verlag "Die Glashütte, Dresden, 1937. viii + 103 pp. Price 3 Rm. Reviewed in *Jour. Soc. Glass Tech.*, **21** [85] A229 (1937).—An account is given of the diseases and accidents to which the various workers in the glass industry are subject and of the possible preventive measures. The evolution from hand to machine production in the making of sheet glass, tubing, and bottles and the improvement in working conditions thus brought about are outlined. G. emphasizes the value of careful planning of a plant, with a view to the workers' health and comfort, and shows how these considerations go hand in hand with efficiency in other directions. The numerous works photographs are interesting and good. The short work contains some irrelevant matter, and much of what is said is obvious, but it gains value from its systematic presentation. G. makes good his claim to fill a gap in the otherwise copious literature of glass. Those engaged in the management of welfare work and the workers themselves can hardly fail to pick up a few useful hints. See *Ceram. Abs.*, **16** [3] 88; [6] 191 (1937).

Reports of the Progress of Applied Chemistry: Vol. 21 (1936). SOCIETY OF CHEMICAL INDUSTRY, London, 1937. 875 pp. Reviewed in *Nature*, **140** [3532] 49 (1937).—New contributors are M. B. Donald (general, plant, and machinery), J. Grant (pulp and paper), and J. A. Sugden (refractories, ceramics, and cements). A report by W. E. S. Turner on glass is included. There are 26 sections with general name and subject indexes. J.L.G.

PATENT

Insulating structure comprising vermiculite. GLENN SUCETTI AND R. M. KOHR. Can. 365,298, April 13, 1937 (Sept. 13, 1935). A muffler has a wall made of heat-expanding vermiculite mixed with clay, the mixture having been plasticized, formed, and heated to at least 1300°F. G.M.H.

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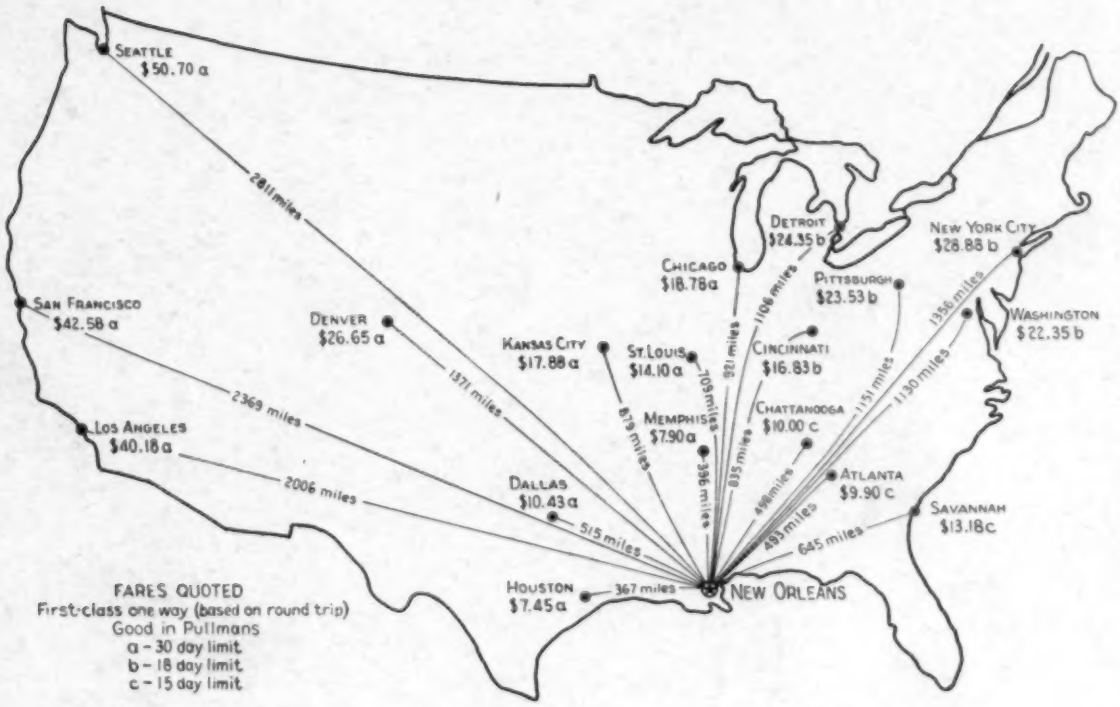

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